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MONTHLY REPORT ON MARS.

WILLIAM H. PICKERING.

Introduction.

The Jamaica Astronomical Station of Harvard College Observatory, where the observations described below were made, is located near Mandeville, Jamaica, in longitude $5^h\ 10^m.2$ (77° 33′ W), latitude 18° 01′ N, and at an altitude of 2100 feet (630 metres). The instrument employed is an 11-inch (28 cm) Clark refractor, loaned to the observatory by Mrs. Henry Draper. The magnification used in all cases, unless specified to the contrary is 660.

The only planetary bodies in the solar system whose surfaces present to us constant physical change are Jupiter, the Moon, and Mars. The changes on the first are easily seen, but are due simply to shifting cloud masses; those on the second are rather difficult to observe, on account of the confused character of the surface detail when seen under high illumination, which is the only condition under which these changes occur. The changes upon Mars cannot be described as conspicuous, except when the planet is viewed under very favorable conditions, but in their general character they may be detected by careful study, even by those who are not fortunate enough to reside in those portions of the world where the seeing is habitually good.

In order to emphasize this constant change, in the case of Mars, and show its resemblance to what we find occurring upon the Earth, it occurred to the writer that it might be of general interest to publish a regular monthly report under the above heading, until the planet becomes so remote that it can no longer be observed to advantage.

This is the first time, it is believed, that it has been proposed to report regularly the news from another planet. In order that the expectations of the readers of this column should not be unduly raised, however, it should be stated at once that the news will consist mainly of meteorological items and I would have added "crop reports", except that this latter term would

seem to imply artificial cultivation. Meteorological changes undoubtedly occur on Mars, and vegetation undoubtedly progresses with the seasons, but whether this progress is of such a character as to imply artificial direction we have as yet no means of knowing. It is in fact one of the objects of this column to put before astronomers and the public in general at as early a date as possible the nature of these changes, as far as they may be determined. Each individual can then make up his own mind whether it is necessary to call in artificial cultivation in order to explain them, or not.

After each opposition of Mars of late years we have received various reports from different observers, of the changes in the appearance of the planet which they have noted since the previous two or three oppositions. Each opposition, however, presents the planet in a different portion of its orbit, and consequently at a different season as well as in a different year. That the planet's surface changes both with its seasons and also in different years is now so well known, that the reports give us no new light on the planet's physical economy, although the facts recorded are of value for future reference. The present plan on the other hand proposes to differentiate these two changes from one another, giving us only the seasonal change. It will also give us another change, namely that taking place from day to day, when this is sufficiently conspicuous to be of interest. Changes of this third kind are necessarily mainly meteorological.

With regard to nomenclature, the terms "seas", "canals" and "lakes" will constantly be used. The last two names were originally applied by Schiaparelli, although both the canals and lakes were originally discovered by Beer and Maedler. When the canals first appear in the spring they are comparatively broad markings. As the season progresses they become very much narrower and finally disappear. It is practically certain that both the canals and lakes as well as the seas are due to vegetation, but it is not at all clear that the surrounding region is an absolute desert, as it changes appreciably in redness, and also in brightness, from time to time. That the canals are bounded by straight lines, or even smooth curves is by no means certain, indeed it is exceedingly doubtful. Such usually appears to be the case, however, owing to our insufficient optical power. The writer has never yet seen the canals double, although he has observed the planet many times under most favorable conditions. Something analogous has, however, been seen upon the moon.

Clouds are nearly always visible upon the disk, but they are not usually reported, because they are difficult to observe. This, oddly enough, is on account of the lack of contrast in color between them and the soil. That is to say the clouds appear to be yellow, and not

white, as we should naturally expect. This is probably because they do not occur in solid masses, but rather as groups of individuals, between which we see the surface of the planet. While each individual may be as much as several miles in extent, yet they are not seen separately as such, the combined effect being to brighten the whole region while affecting its color but slightly. In the polar regions the clouds are sometimes so white, as to be with difficulty distinguished from the snow. They are believed to be clouds since they usually have hazy boundaries, since they are seen to shift, to form, and to disappear and sometimes to project beyond the limb and terminator. After they have disappeared at the poles, the ground is often seen to be white with freshly fallen snow.

The clouds are sometimes so widespread and numerous, or perhaps so thin, like our cirrus, as to partially conceal the detail of a whole hemisphere. This was the case in 1894, and again at one of the more recent oppositions. Photography shows (Harvard Annals **53**, 167) that an equatorial belt of cloud is often present, but this must be very thin, since it has not as yet been observed visually. As regards color, it may be noted that our own terrestrial clouds are by no means as white as snow. Sometimes when the sun is low and behind us, two clouds may be seen, the nearer of which is much darker than the other, though it is not possible for either of them to be in shadow. The cause of this seems to be a matter of theoretical interest which has been neglected by our meteorologists.

The more conspicuous Martian clouds lie along the limb of the planet, where their existence can be most readily detected by their irregular distribution. They are also found upon the terminator, especially near opposition, but on account of their wider separation from one another they are not so conspicuous there as upon the limb. Since they are found both at sunset and sunrise, it is believed that cloudy nights are not infrequent upon the planet. On account of its comparatively low pressure, the atmosphere of Mars must at certain seasons contain a larger proportion of water vapor than that of the earth. Some of this would be precipitated at night by the cold, and cloudy nights are therefore what we might naturally expect.

It is believed that the annual circulation of moisture from pole to pole takes place upon Mars as upon the Earth, chiefly by floods and through the atmosphere. Upon the Earth our floods are taken care of, except in a small way, cosmically speaking, by our oceans, but on Mars they must be much more severe. Even upon the Earth, however, where large masses of land occur and the snow fall is heavy, as in Siberia, the spring floods offer a startling demonstration of the intensity of our sunlight. Compared to one of these huge Siberian

freshets, our own western floods sink into insignificance. On Mars it is thought that the first description of one of these semi-annual cataclysms is given in Astronomy and Astrophysics, 1892 **11**, 668. At the present writing another one is in progress, this time starting from the north polar cap. An account of it will appear in our next report.

We have no means of knowing what is the pressure of the Martian atmosphere, but as far as observational evidence is concerned it might differ from that of the earth only in proportion to the intensity of gravitation at the surfaces of the two planets. On a clear night we find from a series of observations that southern stars of the fifth magnitude, crossing our meridian at an altitude of 7° to 8° have the same brilliancy as stars of the sixth magnitude near the zenith. Their light is therefore reduced by sixty per cent. If our earth were viewed from such a distance that its angular diameter was 15″, then the brilliancy of its surface would be reduced by sixty per cent at a distance of 0″.3 from the limb, that is in those portions of the world where the atmosphere was perfectly clear. Whether the light of Mars at this distance from the limb, where unaffected by clouds, is reduced as much as this, we have no means of knowing, but it is certain that the best photographs show some falling off of the light as we approach the edge of the disk, when no planetary clouds or haze are present. Over the high plateau of the Andes, in western Bolivia, the cumulus clouds rise to a height of six miles above sea level. If the Martian atmosphere were equal to our own, on account of the diminution of the surface gravity, we should expect them to rise two and a half times as high. The best observations of clouds on the terminator indicate an altitude of fifteen to twenty miles. While our present information is quite inadequate to settle the question of the surface pressure of the atmosphere of Mars we may conclude that it is likely to lie between one-half and one-tenth of that found at the surface of the earth.

The canals and lakes of Mars are never visible with any aperture however large, unless the seeing reaches at least 8 on the writer's "Standard Scale". Since it is believed that this quality of seeing is never attained in our northeastern states, it is hopeless for readers in that section of the country to look for them. Certainly the writer has never succeeded in seeing them at Cambridge. He has with a 6-inch aperture, however, and a magnification of 300 to 400, been able to see the changing colors upon the disk, especially the greens of early spring, which are now beginning to appear, and the variation in size of the polar caps.

An early paper on the planet's meteorology is given in the Harvard Annals **53**, 155. I believe the subject has not been treated by

other observers. The earliest, perhaps the only detailed account of the color changes on the planet will be found in Astronomy and Astrophysics 1892 **11**, 449 and 545.

In describing what he sees, the writer proposes to use terrestrial terms, but if the reader feels doubt as to their correct interpretation, for the word "snow" he may substitute "white spot", for "cloud" "bright yellow or yellowish white spot," and for "vegetation" "grey or green spot." Each month the changes described will be preceded by a table giving the data of the observations. The observations themselves will be described under four headings: Snow, Clouds, Colors and Shading, Canals and Lakes. It is to be noted that with the approach of daylight the surface of the planet becomes strikingly more red in appearance, all observations of color, in order to be comparable, must therefore be made while the sky is still dark. The daylight color is, however, undoubtedly the true one. The surface of the planet will be divided into six sections, each section extending through 60° of longitude, as follows:—

Section	**1**	330° to 30°	Section	**4**	150° to 210°
"	**2**	30 " 90	"	**5**	210 " 270
"	**3**	90 "150	"	**6**	270 " 330

In describing the canals and lakes the date of each observation will be followed by the number of the section in which the central meridian of the disk lay. The changes that occurred in each section can thus be more readily detected. Reference to the visibility of other features of the planet, such as "gulfs" and "regions" will occasionally be made under this heading.

In the following table of data the first two columns give the number of the observation and its date, the third the heliocentric longitude of the planet, and the fourth the corresponding equivalent date in the terrestrial year, based on Professor Lowell's determination that the Vernal Equinox of Mars, corresponding to March 20 for the earth, lies in heliocentric longitude 86°. The fifth column gives the longitude of the central meridian of the planet, the sixth the latitude of the center of the disk, and the seventh the same as seen from the sun. The eighth column gives the angular diameter, and the last the quality of the seeing on the writer's Standard Scale, described in the Harvard Annals **61**, 29, extended to 12, 10 being perfect for a 5-inch (12.7 cm) aperture, and 12 for one of 11 inches (28 cm).

Report of Observations extending from July to November.

TABLE OF DATA.

No.	1913	H.L. °	T.D.	Long. °	Lat. °	Sun °	Diam. ″	Seeing
1	July 27	18	Jan. 11	180	−10	−22	6.2	10
2	Aug. 6	24	" 17	92	− 8	−21	6.5	8
3	" 14	29	" 22	4	− 6	−20	6.7	9
4	" 25	35	" 28	262	− 3	−19	7.0	6
5	Sept. 2	40	Feb. 2	183	− 1	−17	7.2	10
6	" 13	46	" 8	80	+ 2	−16	7.6	8
7	" 17	49	" 11	36	+ 3	−15	7.8	8
8	" 30	56	" 18	258	+ 5	−12	8.4	9
9	Oct. 12	62	" 24	160	+ 7	−10	9.1	9
10	" 19	66	" 28	94	+ 8	− 9	9.5	8
11	" 30	72	Mar. 6	346	+ 9	− 6	10.3	9

SNOW.

When first observed no snow could be detected upon the planet, but the north polar zone was enveloped in cloud, as indicated by its bright yellow color, and the pole itself was turned away from us, as shown by the table, at an angle of 10°. The south polar zone was distinctly reddish, as far as the pole itself, and was apparently clear of cloud. August 14 a greenish white spot was seen in the extreme north, extending along the limb some 20°. It was whitish for about 20° farther, and then faded into yellow. The greenish white is probably a contrast effect, and quite different from the greenish grey due to vegetation, which will be noted later. This seems to have been the first appearance of snow. Its diameter was 1300 miles, assuming it to continue past the terminator in the same direction to the limb. This would indicate that the snow cap had at this time reached as far south as mean latitude 72°. At the next observation the pole was enveloped in cloud, but by September 2 a slight greenish tint was again seen, and the border was sharply defined against the reddish yellow of the soil. Diameter 1800 miles. Latitude 65°. On September 13 and 17 small areas of snow were visible through the clouds at the north, and on the latter date it was suspected through the clouds at the south pole as well. The center of the south polar cap does not coincide with the geographical pole, and the cap itself is more or less permanent. At the time of this observation it would be turned towards us as much as possible.

September 30 the snow was clearly seen at the north as a white patch, measuring 1700 miles in diameter. Latitude 67°. Vegetation beginning to spring up along its edge, or else marshy dark soil, forms a narrow irregular grey band, but not of the blue black intensity which is seen later in the season as the result of melting. October 12 the north polar regions were again of a yellowish color indicating cloud, but the grey border was more uniform and pronounced than before. Diameter of the snow 2300 miles. Latitude 58°. October 19, clouds at the limb

yellow; over the snow whitish yellow. Diameter of snow 2100 miles. Latitude 61°. October 30, the northern white spot was at first described as greenish, but an hour later as drab or yellow, and not particularly bright, less bright in fact than a small area near the south pole, which was perhaps really snow. Diameter 2600 miles. Latitude 53°.

Clouds.

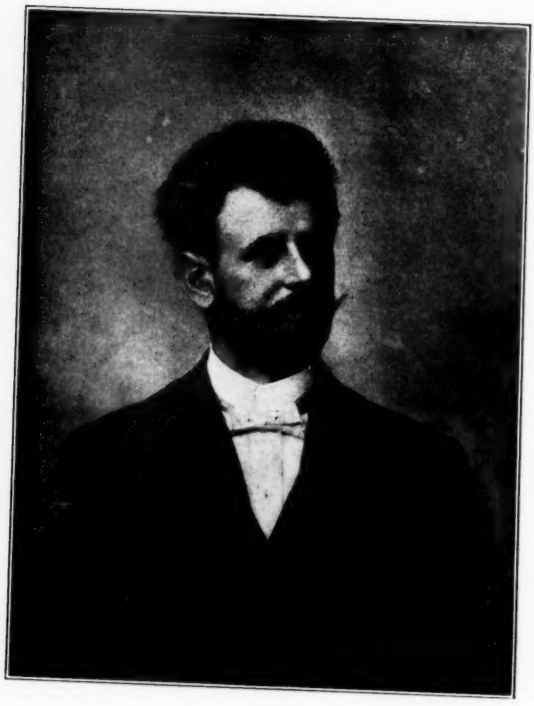
In July the only cloud detected was towards the north pole. August 6 it extended along the limb as far as the equator. August 14 it was unusually cloudy, 0.4 of the surface of the disk being enveloped in cloud. The north polar zone was practically clear, but the cloud nearly reached the central meridian in the north temperate. The south temperate zone was the clearest of all, while the south polar was completely clouded. September 2 the disk was largely free from cloud, only the south polar and the southern part of the south temperate zones being still enveloped. It is probable that a narrow strip of cloud extended the length of the limb, but was not over 0″.3 in breadth. September 13 the cloud band along the limb was 0″.8 in breadth increasing to 1″.3 in the south temperate zone. General Martian haze. September 17 the cloud band along the limb had further increased in breadth to from 1″.0 up to 1″.2. September 30 two very sharply bounded luminous cloud masses stretched along the limb, the larger for about one thousand miles in the south temperate zone, the other near the equator. From the latter a band of less brilliant cloud 0″.8 in breadth reached to the south polar cap, which seemed to be free of cloud. Even in the course of a couple of hours these clouds materially changed in shape, size, and brilliancy. October 12 a little cloud extended along the limb, but it was not continuous. October 19 the cloud over the planet was clearing, only a little lay along the limb, and none in the south temperate zone, which at this season of the year seems to be the clearest part of the planet. The band varied in breadth in different latitudes from 0″.8 to 0″.3. October 30 the same description applied, but more cloud was now found to the south and less to the north than before.

Colors and Shading.

In the first observation the surface south of the southern seas was quite as red as to the north of them. In the second the red still persisted, but by August 14 it had become very faint. August 25 the color is described as orange, turning again to red September 2. September 13 the red is very faint as if seen through a general Martian haze. This longitude on the planet, which generally presents very clearly marked details, was extremely indistinct through Octobor. A very slight darkening just to the south of the clouds covering the northern snow

cap was detected, and this became much more pronounced and extended in the next observation, September 17. The snow cap was still covered and the darkening was broad and faint, but extended now across the north temperate zone following the course of the Ganges to Auroræ Sinus. Its breadth was about 400 miles where it crossed the equator. This was the first evidence of the arrival of moisture from the north pole. Whether the darkening was due to vegetation or merely a change in the color of the soil, due to moisture, is not clear, but it apparently persisted, for at the next presentation of the region, October 30, it was if anything still more clearly marked, and had now broadened in a preceding, that is westerly, direction as far as Sinus Sabaeus, and measured some 1500 miles in width. On September 17 there was no red or even orange visible upon the planet, only yellow and grey, the former a little deeper towards the center of the disk, and the grey only faintly marked. A general haze seemed to envelop the whole planet. September 30. The clouds had now cleared from the snow, and a very narrow dark line bordering it on the south was seen for the first time. This was the first direct evidence of its melting. Although the snow was perfectly clear on September 2 and this line was then looked for, as we knew it should soon appear, it could not then be seen. The two canals, Hyblaeus and Nilosyrtis, appeared in the sketch of September 30, connecting the dark line with the northern seas. The former was 180 miles in width and led nearly due south to Hephaestus. The other was perhaps two-thirds as wide, but much darker, and led to a very dark large area in the Syrtis Major. The line bordering the snow was some 200 miles wide at the Fretum Anian west of Hyblaeus, but less than half that width to the east of it. The whole region north of Cimmerium and as far as Elysium, extending from the Sinus Titanum to the Syrtis Major, was dark, Libya and Aethiops, being of a lighter shade. The dark areas seem to spread to the north in these longitudes at this season. On October 12 a forked broad faint shading proceeded north-east and north-west from Titanum following somewhat the course of Tartarus Gigas. It was not seen again either before or after this date. The more striking features of October 30 have already been mentioned, but in addition we may note that the line bordering the melting polar cap had now so far broadened as to be described better as a band than a line. Its breadth varied in different places from 350 to 700 miles. At the Acidalium Mare it had so far darkened as nearly to equal Sabaeus, and the snow cap was clearly notched at that point. At the former presentation of this region, September 17, not a trace of this very conspicuous marking was visible.

PLATE II



JOH. NEP. KRIEGER

1865-1902.

CANALS AND LAKES.

July 27. **4** Cerberus and Erebus suspected rather than seen.
Aug. 6. **3** No identifiable detail.
Aug. 14. **1** Sinus Sabaeus.
Aug. 25. **5** Syrtis Major.
Sept. 2. **4** Cerberus, Orcus, Erebus, Antaeus, named in the order of visibility, the first being the most conspicuous. Trivium Charontis.
Sept. 13. **2** Fortunae, Chrysorrhoas, Ganges, Pithonius Lacus, Lunae Lacus. All very faint.
Sept. 17. **2** Ganges very wide and clearly marked. In strong contrast to its appearance four days earlier. The other canals and lakes had disappeared.
Sept. 30. **5** Nilosyrtis, Hyblaeus, Eunastos. The regions known as Libya and Aethiops were clearly shown and slightly shaded.
Oct. 12. **4** Gigas, Tartarus. Both very broad and faint. Sinus Titanum, Trivium Charontis and Ceraunius, the first very distinct.
Oct. 19. **3** Tithonius Lacus. The whole region south of it was dark, and it is surprising that neither Solis Lacus nor Lacus Phoenicis, both usually very marked features, and both near the central meridian, should be visible.
Oct. 30. **1** Orontes drawn, but described as uncertain. Sinus Sabaeus Sinus Aurorae, and Acidalium Mare clearly shown. Deucalionis Regio was also seen.

The canals most clearly visible during the three months covered by these observations were Cerberus, Erebus, and Ganges, each recorded twice, and Nilosyrtis and Hyblaeus, each recorded once.

Mandeville, Jamaica, W. I.
Dec. 4, 1913.

JOHANN NEPOMUK KRIEGER.*

There can be no greater tragedy in scientific history than the death of an enthusiast who had just realised what should be his life-work and had just fitted himself to begin it in real earnest. Such a man was Johann Nepomuk Krieger, and such, almost, was his fate. He had, indeed, done two or three years' real work on the moon, which has fortunately been preserved for us; but it provides only imperfect material for one or two of the eight volumes which he had projected and serves chiefly perhaps to show what a loss the astronomical world

* From an Oxford Note Book (H. H. Turner) in *The Observatory*, August, 1913.

suffered by Krieger's death in 1902, at the age of 37. But for the rare devotion of another worker we might not have had even this.

Krieger was born at a little town in Bavaria in 1865, the son of an inn-keeper. He was early drawn to Astronomy, and found his way to Professor Seeliger in Munich. The mathematical side of the science did not appeal to him, but when it came to studying the surface of the moon he had so little doubt about a "call" that he sold his paternal property, settled in Munich, and began his work (in 1887). But the climate did not give him opportunities enough, and after sampling several he ultimately (1895) built an observatory at Trieste, naming it in honour of his wife. In November 1897 he published (as a private venture) a volume of his drawings, and foreshadowed the publication of seven more. He knew by this time just what to do, he said; he saw at least eight to ten years' work ahead of him, and he settled down to do it with immense energy. Alas! within a third of that time disease had firm hold of him, and his death soon followed,

It was not until the autumn of 1908 that his widow, who had meantime remarried, put the results of the diligent work in the years 1897 to 1900 into the hands of Dr. Rudolf König. Seldom can a better choice have been made for a difficult office. The papers were not in good order, many of them being without date or other means of identification: some were obviously missing, and were only traced into the posession of a former fellow-worker a year later. Dr. König was, moreover, himself not very familiar with the kind of work and felt it a duty so to render himself by two years' diligent observation with a telescope as nearly like Krieger's as he could get. Nevertheless, he has managed to give us within five years of his entry upon the undertaking, two beautiful volumes, one containing the reproductions of Krieger's drawings and sketches, the other the requisite letterpress,—the whole* an admirable example of posthumous editing.

The volume of text contains an Introduction which Krieger had himself prepared, and which gives an account of his methods of work. He had a 10-inch refractor, but he found it better to cut it down to 6½ inches, since with full aperture he found that his eye quickly lost all

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* Krieger, J.—Mond-Atlas, new series, edited by R. Koenig, portrait and 31 engravings, with atlas of 58 plates, transparent key maps opposite each and a general map of the moon (diameter of disk 16½ in). 2 vols., roy. 4to., cloth: W. Wesley & Son, 1912. Price £3 5s.

Supplements the first series, issued in 1908, and contains all the deceased Author's later work, under the editorship of R. Koenig. The text (in German) gives the needful explanations of the plates and descriptions of the single objects with dates and sketches. The atlas contains more than 800 rills and rill-like objects. The plates are on a scale which gives a disk of the moon 118 to 158 inches in diameter.

PLATE III

THE LUNAR CRATER GASSENDI

From KRIEGER'S *Mond-Atlas*. Scale: 1 mm = 2060 m in longitude = 1330 m in latitude.

the fine detail which it glimpsed at the first instant. With 6½ inches he could hold the detail steadily. He made his drawings on photographs of the region suitably enlarged. By experience he had arrived at a knowledge of the convenient scale and density of such enlargements when they were to be used at the telescope, and preferred to prepare them himself. He seems not to have considered it important that the libration should correspond very closely to the moment of observation; indeed, he had not many photographs to choose from, and determined to work with what he had rather than loose fine nights. This led to his regarding the date and origin of the photograph as of minor importance, so that they were not recorded in many instances. There is, for example, an elaborately careful drawing of Gassendi (No. 46) the photographic basis of which is "unbekannter Herkunft." This attitude will doubtless be regarded by more methodical workers with impatience; but there can be little doubt that it represents not carelessness, but rather deliberation on Krieger's part. He regarded his work as that of an artist—it must be his own entirely, uninfluenced by the knowledge of other work. He remarks that to make a drawing after studying previous drawings of the same region would result in something like the compositions of a musician in which the themes of other composers could be always heard. He used a photograph as a convenient basis to keep his picture sensibly correct; but he probably (although he does not explicitly say so) preferred a photograph which showed as little detail as possible, so that he might make his additions with the greater independence. And this course may easily be justified. There is, for instance, at present under construction (a considerable part already drawn by the skilful hand of Mr. Wesley) a map of the moon in mean libration, under the auspices of the Lunar Nomenclature Committee of the International Association of Academies. It is hoped that this may ultimately serve as a basis for the drawings of observers at the telescope. But if so they will have to neglect the actual libration, as Krieger did.

In spite of its incompleteness, nay, rather perhaps because of it, Krieger's work will surely act as a stimulus to others. We have the explicit testimony of Dr. König that admiration for it grows with familiarity. From internal testimony we can learn how the enthusiasm of the worker himself grew. At first he contented himself with two or three sketches in the same night, winding up the year 1897, however, with six (on December 31). But on January 12, 1898, he made eleven; and on four nights, April 28 and 30, May 1 and 2, he made no fewer than thirty-nine altogether. There were great bursts of activity also in August, September, October, and December (thirteen sketches on Christmas day); and so on till his health and strength failed. He accomplished but a fraction of what he hoped, but how long will it be before his work

is surpassed? When Carrington made his determination of the position of the Sun's axis, he prophesied that no one would better it without expending some £10,000: and fully that amount of money has flowed under the corresponding bridges to obtain substantial betterment. Krieger has made no such forecast: but one might almost venture to make one for him. Unless Dr. König were to follow up his present achievement by continuing the work on his own behalf: is that a fortunate possibility?

NOTE ON TWO SPECTROSCOPIC BINARIES.

EDWIN B. FROST.

(1) The star 20 π Cassiopeiae ($\alpha = 0^h\ 38^m$, $\delta = +46°\ 29'$. Mag. 5.0), which I have lately found to be a binary, is of a little more interest than the ordinary binaries we constantly pick up in our routine work because of the rather wide range of velocity exhibited. Both components show lines not differing much in intensity, but those of the one are somewhat broader than those of the other. The spectrum is of type A5.

We have thus far secured only four spectrograms, and I have measured these. The first plate on July 21, 1913, gave velocities of -97 (broader component) and $+147$ km, or a range of 244 km; the fourth plate, taken on September 10, resulted in a still larger range, the narrower component -112 km, the broader $+143$ km. Plates of Aug. 1 and Aug. 4 gave intermediate values, with the components reversed in direction. The period is probably short. Few stars have thus far been found with larger range.

(2) The star 10 Lacertae ($\alpha = 22^h\ 35^m$, $\delta = +38°\ 32'$. Mag. 5.0) has a spectrum of particular interest because of the sharpness of the line of the hydrogen series, λ 4686, which Professor Fowler has lately produced in the laboratory. The Harvard classification is Oe 5. This line is found in many spectra of the helium type, but it is much better measurable in this star than in any other with which I am yet familiar. A preliminary value of the wave-length was communicated by Mr. Adams and myself to the Washington meeting of the Astronomical Society in 1902. The star has been kept on our observing list and I have lately measured all of the new plates in collaboration with Miss Frances Lowater of Rockford College, Volunteer Research Assistant at the Observatory in the summer of 1913. My earlier suspicion as to the star's variation in velocity is confirmed. A range of from -19 km to $+1$ km

PLATE IV

THE NETWORK OF CRACKS NEAR THE LUNAR CRATER TRIESNECKER

From KRIEGER'S *Mond-Atlas*. Scale: 1 mm = 1975 m in longitude = 1975 m in latitude.

has been observed among the score of plates available. Several other important stellar lines are well defined in this spectrum so that their wave-lengths have also been determined.

A star with constant velocity would have the preference for such purposes, but in every case the wave-lengths sought must of course be corrected for the velocity of the star with respect to the observer (i.e., before the correction of the earth's velocity has been applied). The resulting value for the line λ 4686 will agree quite well with Professor Fowler's laboratory value. The definitive results will be soon published in the Astrophysical Journal.

It may be of interest to say that there seems to be no falling off in the number of spectroscopic binaries found in our routine work with the Bruce spectrograph (one prism arrangement), which is at present chiefly devoted to A (and some B) stars of visual magnitudes 5.0 to 5.5.

Yerkes Observatory, Nov. 19, 1913.

METHODS OF RECEIVING THE ARLINGTON WIRELESS TIME SIGNALS AND COMPUTING THE LONGITUDE.

WILLIAM F. RIGGE.

In the preceding, December, number of POPULAR ASTRONOMY I described an efficient and inexpensive aerial for receiving the Arlington wireless time signals. In the present article I will mention various combinations for comparing these signals with the home clock, and explain the method of deducing the longitude.

1. The current of one dry cell may be sent through the clock and primary of a small converter, the secondary of which must be stepped-down considerably before its current is sent into the telephones. The one that I used was made to transform 110 volts A.C. to single volts as far as eleven and even to quarter volts. The primary consisted of 1820 turns and had a resistance of 26 ohms. The secondary was made up of ten sections of 18 turns each, giving approximately one volt for each section, and also of four sections of five turns each giving quarter volts. For use in the telephone one quarter-volt section was sufficient, and even somewhat too loud. Owing to the low resistance of the primary, the battery weakened too soon on the break-circuit system. This might be remedied by having other cells at hand or by introducing resistance.

2. The clock could be heard in the telephone when only one second-

ary wire was connected to it, and even when no wire at all was used. The converter was near the receiving apparatus, but its wires were nowhere near the antenna wire.

3. The clock could be heard as well when a 150-ohm relay magnet was in circuit with it and one cell, and one wire connected any part of its circuit to a telephone wire.

4. My telephones being across the fixed condenser, I can hear my clock in series and in shunt with the telephones, but the Arlington signals and my clock together only in series.

5. The strangest of all is that I can hear my clocks when they are connected to the telephones only, without any battery whatever, and when the chronograph battery, which is located at the college and might possibly send some stray current into the wires, is entirely disconnected. In order not to extend this article too far, I must here omit several pages of interesting details.

6. Another method used was to send the current of one cell through a clock, a high resistance and one telephone, using the other or both for Arlington. This is the scheme described in the Circular Letter of the Superintendent of the Naval Observatory, to which I am much indebted. My resistance of 6000 ohms was not quite heavy enough. This is probably the most reliable method, although my favorite one is to have the solar clock in series with Arlington.

Method of Observing and Computing.

My method of observing the Arlington signals at the college station, is that a few minutes before they come in, I listen to the beats of my solar clock in the telephone and set the second hand of a stop watch in synchronism with it. This relieves me of the burden of counting the beats, and gives me a larger and more adjustable second-hand than a common watch presents, and even indicates fifths of a second. The stop arrangement I never use except for obtaining or re-establishing the synchronism, in case the watch rate should not have been well adjusted.

As soon as the Arlington signals begin and my receiving apparatus is in good working order, I note the coincidences and the pauses. With a solar clock the coincidences occur at intervals of about a minute and forty seconds or so, and the Arlington interruptions or pauses at almost the same second of succeeding minutes. With this knowledge the strain of observing is reduced considerably. I then note down the second of every coincidence and of every first Arlington signal after an interruption. I find the latter less fatiguing than noting the time of the last signal or of the interruption, although here opinions may differ. There are, of course, no fractions of a second in the coincidences, and they may be ignored also in the pauses. The minute is obtained either from

the stop watch itself, or from another watch or small alarm clock, the precaution being taken to set the minute hand accurately on a mark when the stop watch shows the zero second.

As an example of a night's work and its reduction, I will select my second one, when I used a stop watch for the first time. As the Arlington signals come in three sets of seven minutes each, beginning at 6:46, 7:06, 7:26, central time,* the present observations show a defective first set, a complete second one, and no third. One observed coincidence and one known signal or pause constitute the minimum, although the more signals noted the better the results. On the night selected, November 22, 1913, I observed the signal just before the pause, and caught also the first signal in the first set.

Coincidences			Radio Number	Signal before pause			Radio Number
				First	$0^h\ 10^m\ 18^s$		1
					11	16.2	59
I	$0^h\ 12^m$	4^s	107		12	16	119
	13	44	208		13	50	
				Last	17	13.8	420
	31	0	45		31	14	59
	32	42	148		32	14 ?	119
II	34	16	243		33	13	179
	36	4	352		34	12	239
					35	11.8	299
					36	11	359
				Last	37	11.2	420

As the Arlington signals are numbered from 1 to 420 in each set, numbers 0, 60, 120, 180, 240, 300, 360, being the pauses or omitted ones, 420 the last signal, and a few at times preceding the 0, we must begin by identifying our pauses or the signals preceding or following, as we have observed them.

The last signal in each of the preceding sets having been noted as such, we mark it 420, as has been done in the last column to the right under the heading Radio Number. The next one above it, in the second set, $36^m\ 11^s$, precedes the pause 360, and is therefore No. 359. As all the pauses have been noted in the second set, their radio numbers are easily affixed.

As the first set is defective, we get the radio numbers by noticing that the sets are displaced almost exactly 20 minutes, so that $11^m\ 16^s.2$ in the first set must be No. 59, since it is close on 20^m before $31^m\ 14^s$ in the second set. In like manner $12^m\ 16^s$ must be No. 119, and $13^m\ 50^s$ must be rejected, because its 50^s is so far from the others in the same column that it cannot be genuine. My note book says that the detector gave

* This schedule was changed on December 1, and may be changed again.

trouble at the time and was not adjusted until near the end of the set. We ought also to reject all doubtful observations, such as $32^m\ 14^s$. Computation will show this to be a second wrong.

The next step is to give radio numbers to the observed coincidences. This is done with reference to the pauses. The first coincidence, $12^m\ 4^s$, came 12 seconds before the signal preceding the second pause, and as the latter is No. 119 the former must be $119-12=107$. Similarly the second coincidence, $13^m\ 44^s$, came $1^m\ 28^s = 88^s$ after this same signal and must be $119 + 88 = 207$. But as the Arlington signals are not true seconds—we might call them radio seconds—but are about one per cent shorter, running 101 in about 100 seconds, we must add one per cent to the 88 and make it 89. Hence the corrected Arlington number is $119 + 89 = 208$, and is so marked in the second column. It is advisable always to connect the coincidences with their nearest pauses, in order to avoid the ambiguity that may occur when the radio signal is separated about half a second from the home clock and only whole seconds are marked in our note book, because then we are as likely to choose the preceding as the following second, and this would introduce an error of $0^s.99$ into our result. In the present instance, of course, there was no other way.

The radio number of a coincidence may be found from the known number of any one signal or pause in its set. For example, the last signal of the first set, No. 420, was observed at $17^m\ 13^s.8$. The first coincidence, $12^m\ 4^s.0$, came $5^m\ 9^s.8$ or $309^s.8$ before it. Adding one per cent to these seconds, we get 313 as the nearest integer. Hence $420-313 = 107$ must be the radio number of the first coincidence. This tallies perfectly with the other method.

As the coincidences can be observed with great precision, and an error of one second in locating one properly carries with it an error of only one-hundredth of a second in the final result, we must now by their means find the exact time of Radio Numbers 1 and 420, that is, of the first and last Arlington signal in the set. The pauses or individual radio signals serve merely to give our coincidences their proper Arlington number and cannot be observed with greater precision than that afforded by the ordinary chronographic method.

Taking up the first coincidence at $0^h\ 12^m\ 4^s.00$, which like all the rest was observed at a full second of the home clock and is presumably correct to the hundredth of a second, we saw that it is No. 107 in its series. The last signal being No. 420, there are $420 - 107 = 313$ "radio seconds" between them. This radio second was said to be $0^s.99$. We must now however find its length more accurately in terms of our own clock.

In the interval between two successive coincidences, the Arlington clock gains one beat on the home clock. This Arlington clock, by the way, is most likely little more than a pendulum with just enough of wheel work to keep it going and produce its signals and pauses, since a gaining rate of one per cent would set it forward 14 minutes 24 seconds in a day, unless of course, it is a clock devoted to this exclusive purpose. Its object is merely to establish convenient coincidences with ordinary clocks, since it gains one beat in about 102 on a solar clock and one in about 142 on a sidereal one. The observations given above show that the observed coincidence interval was 100 seconds in the first set, and 102, 94, 108, in the second. The latter look bad but will turn out pretty well. Instead of taking the average of these four intervals, the best way is to find the interval from coincidences as far apart as possible. As the Arlington clock keeps on going even when not sending signals, we are able to use our very first and very last observed coincidences, even when they belong to different sets. Hence, as in our case the interval between the first coincidence, $12^m\ 4^s$, and the last, $36^m\ 4^s$, was $24^m\ 0^s.00$ or $1440^s.00$, we use 102^s as a trial divisor—because the times were observed with a solar clock—and find 14 to be the nearest integer. Hence 14 coincidence intervals have occurred between our first and last observed coincidences. Dividing our $1440^s.00$ by 14 gives us $102^s.857$ as the accurate average length of our coincidence intervals.

Now in these 1440 solar clock seconds there were $1440 + 14 = 1454$ radio seconds, because the latter are one more in each interval. Hence dividing these 1440 solar seconds by the 1454 radio seconds gives the length of one radio second equal to 0.990375 seconds as told by the home clock.

Coming back to the first observed coincidence, $0^h\ 12^m\ 4^s.00$, which was 313 radio seconds ahead of the last signal in its set, we find that it was 313 times 0.990375 solar seconds, that is, $309^s.986$ or $5^m\ 9^s.986$ ahead Adding this interval to the observed time, $0^h\ 12^m\ 4^s.00$ gives $0^h\ 17^m\ 13^s.986$ as the time of the last signal in the first set according to the observation of the first coincidence.

Between the first and last signal in any set there are $420 - 1 = 419$ radio seconds, that is, $414^s.963$ or $6^m\ 54^s.963$ of solar time. Hence the time of the first signal of the first series is $0^h\ 17^m\ 13^s.986 - 6^m\ 54^s.963 = 0^h\ 10^m\ 19^s.023$ of the local clock. The interval between the first and last radio signals is, of course, the same for all three sets on the same night.

In like manner we find the times of the first and last Arlington signal according to the second observed coincidence at $0^h\ 13^m\ 44^s.00$. This is No. 208 in its series, $420 - 208 = 212$ radio seconds $= 209^s.962 = 3^m$

29ˢ.962 of solar time ahead of No. 420, giving the time of the latter therefore as $0^h\ 17^m\ 13^s.962$, and of No. 1 as $0^h\ 10^m\ 18^s.999$.

The coincidences of the second set are treated in the same way. The results of all six may now be tabulated as follows.

Coincidence	Radio No. 1	Radio No. 420
	h m s	h m s
	First Set.	
1	0 10 19.023	0 17 13.986
2	0 10 18.999	0 17 13.962
	Second Set.	
3	0 30 16.429	0 37 11.392
4	0 30 16.417	0 37 11.380
5	0 30 16.333	0 37 11.296
6	0 30 16.383	0 37 11.346

In comparing the above computed times of the first signal in the first set, and of the last signals in both sets, with those actually observed and recorded in the note book, as they are given earlier in this article, we see that while the first is a whole second out and must be that much wrong, the other two are within two tenths of a second. The observed times are of course intended only as checks upon the computation and lay no claim to an accuracy greater than a second.

The close agreement of the results obtained came as a great surprise to the writer, who had no idea that such precision was attainable with the means at his command. Even those discordant coincidence intervals of 102, 94, 108 seconds mentioned before, seem to have vanished utterly in these results. As the Arlington signals had been observed that night merely for the sake of practice, and no transit observations had been secured, no further use could be made of these results than as a test of the capabilities of the method. The next step would then have been to compare the stop watch with the solar clock in the observatory and to identify its hour and minutes, the seconds being of course identical. Then regular transit observations would give the correction to the solar clock and admit of expressing the above results in local mean and sidereal time. The superintendent of the Naval Observatory, when written to on the matter, will then in turn kindly give the Washington local times of the first and last radio signal in each set. The differences of these times is then, of course, the difference of longitude between the observer and Washington.

A more rapid and easy, although less precise method of finding the longitude is to observe the 9 P.M. (central time) signals, or those at 11 A.M. if possible. These latter I have never been able to hear. Both come for five minutes every day without exception. There is a signal every second except the 29th, 56th, 57th, 58th and 59th. In the last minute the pause begins after the 50th second, and there is one long signal at the full

hour. These signals are a very great convenience, because they may be compared directly with a clock that keeps standard time, without any computation whatever and without any knowledge of astronomy.

It may possibly be necessary to remark as a final inducement to some hesitating astronomers, that in the observation of these wireless time signals no knowledge whatever of the Morse alphabet and no government license are required.

Since writing the above I have made a very important experiment for which experts predicted certain failure. I have been able to transfer my wireless station from the college to the observatory, using for this purpose the college antennae and extending their leading-in wire 300 feet, 200 of which are in a lead-covered cable along with many other wires, and 160 in an iron conduit pipe under ground. While I was not able to hear Arlington and Key West on the one night on which I tried the experiment, I did hear San Houston in Texas and several other stations. The present most unusual long-enduring fog is probably to blame for the faintness of all signals even at the college station, since it must cause much leakage at the extremities of the antenna.* As soon as fairer weather prevails, I will repeat the experiment with, I hope, complete success. At all events the practical possibilities of wireless telegraphy are very enticing and seem at times to defy the teachings of experts.

THE RADIAL VELOCITY OF THE ANDROMEDA NEBULA.†

V. M. SLIPHER.

Keeler, by his splendid researches on the nebulæ, showed, among other things, that the nebulæ are generally spiral in form, and that such nebulæ exist in far vaster numbers than had been supposed. These facts seem to suggest that the spiral nebula is one of the important products of the forces of nature. The spectra of these objects, it was recognized, should convey valuable information, and they have been studied, photographically, first by Huggins and Scheiner, and recently more extensively by Fath and Wolf; but no attempt has to my knowledge been made to determine their radial velocity, although the value

* Note. This conjecture is most probably erroneous, because Mr. Reinhardt gets Arlington in all weathers, and because whatever wireless troubles I have are due almost exclusively to my galena detector.

† Lowell Observatory Bulletin No. 58.

of such observations has doubtless occurred to many investigators.

The one obstacle in the way of the success of this undertaking is the faintness of these nebulæ. The extreme feebleness of their dispersed light is difficult to realize by one not experienced in such observing, and it no doubt appears strange that the magnificent Andromeda Spiral, which under a transparent sky is so evident to the naked eye, should be so faint spectrographically. The contest is with the low intrinsic brightness of the nebular surface, a condition which no choice of telescope can relieve. However, the proper choice of parts in the spectrograph will make the best of this difficulty. The collimator must of course fit the telescope, but the dispersion-piece and the camera may and should be carefully selected for their special fitness for the work. While the speed of the camera is all important in recording the spectrum, the detail in the spectrum depends upon the dispersion, for obviously a line, no matter how dark it may be, must have a certain magnitude or else it cannot be recorded by the granular surface of the photographic plate. Hence the light must be concentrated by a camera of very short focus and the dimension of the spectral line be increased by using a high angular dispersion and a wider slit, as one in this way attains a higher resolving power in the photographed spectrum.

Although I had made spectrograms of the Andromeda Nebula a few years ago, using the short camera, it was not until last summer that I thought to employ the higher dispersion and the wider slit. The early attempts recorded well the continuous spectrum crossed by a few Fraunhofer groups, and were particularly encouraging as regards the exposure time required. The first of the recent plates was exposed for 6 hours and 50 minutes, on September 17, 1912, using a very dense 64-degree prism, the instrument having already been tried out on some globular star clusters. When making this exposure the brightness of the nebula on the slit-plate compared with that of the clusters indicated that one night's exposure should suffice for the single-prism, and suggested that, by extending the exposure through several nights, one could employ the battery of three dense flint prisms whose dispersion would make it possible to observe the velocity of the nebula. The success of the plate bore out this suggestion. Indeed, upon subsequent examination of this plate it was seen that the nebular lines were perceptibly displaced with reference to the comparison lines. The next plate secured showed the same displacement. Still other single-prism plates were obtained during the autumn and early winter, but the observing program with the 24-inch telescope did not allow an opportunity to carry out the original plan to make the longer exposure spectrogram with the prism train.

These spectrograms are measured with the Hartmann spectrocomparator, using a magnification of fifteen diameters. A similar plate of Saturn was employed as a standard. The observations were as follows:

1912, September	17,	Velocity, —284 km.
November	15–16,	" 296
December	3–4,	" 308
December	29–30–31	" —301
	Mean Velocity	—300 km.

Tests for determining the degree of accuracy of such observations have not been completed, but in rounding off to 300 kilometers in taking the mean one is doubtless well within the accuracy of the observations. The measures extended over the region of spectrum from F to H.

The conditions were purposely varied in making the observations. This was done although it was early noted that the shift at the violet end of the spectrum was fully twice that of the blue end, which should be the case if it were due to velocity.

The magnitude of this velocity, which is the greatest hitherto observed, raises the question whether the velocity-like displacement might not be due to some other cause, but I believe we have at the present no other interpretation for it. Hence we may conclude that the Andromeda Nebula is approaching the solar system with a velocity of about 300 kilometers per second.

This result suggests that the nebula, in its swift flight through space, might have encountered a dark "star," thus giving rise to the peculiar nova that appeared near the nucleus of the nebula in 1885.

That the velocity of the first spiral observed should be so high intimates that the spirals as a class have higher velocities than do the stars and that it might not be fruitless to observe some of the more promising spirals for proper motion. Thus extension of the work to other objects promises results of fundamental importance, but the faintness of the spectra makes the work heavy and the accumulation of results slow.

Flagstaff, Arizona.

THE TOTAL ECLIPSE OF 1914.

DAVID TODD.

Twice this year, the sun's light streaming earthward will be interfered with by known bodies of the solar system directly intervening.

On the 7th of November, the planet Mercury will transit the disk, and on the 21st of August, another total eclipse of the sun takes place. Happening at a convenient season for most observers, we may expect many expeditions to be undertaken.

As a small and brief partial eclipse it will be visible just after sunrise in the northeastern states, the region of the Great Lakes, Canada, and eastern part of British America.*

The continent of Europe is about central in the vast area of the earth where this eclipse at some phase or other can be seen; all of northern Africa and Arabia will witness a partial eclipse of many digits; so will eastern Russia, Siberia and the western half of Asia, as far as India where a very small partial eclipse of the sun will be seen just before sunset, a counterpart of the morning phase seen in America.

But the partial phases have little interest for astronomers today, as compared with the total phase, which in the present eclipse is of only moderate length; but it is regarded as of exceptional interest because it lies almost wholly on land, the most favorable regions of which are in mid-Europe and so quite readily accessible.

To trace the totality track throughout its entire length: the moon's shadow first strikes the earth, that is totality begins at sunrise, at a point in north latitude 72°, directly north from San Francisco. Whence it goes easterly, crossing Greenland about the 77°.5 parallel, thence southeasterly crossing Norway and Sweden at the 64th parallel, where the first available stations are found. Vefsen, Norway, and Sundsvall, Sweden are almost in the centre of the shadow's path, and the eclipse will be total there $2^m\ 8^s$, at about ten minutes after one, p.m., local time.

Traversing the Baltic sea, where a number of islands are favorably placed within the totality track, the shadow reaches Russia nearly centrally over Riga; travels slightly to the east of Kief, where totality will last $2^m\ 12^s$ (within 2^s of the maximum that can be observed anywhere); then on southeasterly and nearly centrally across the Crimea; over the Black Sea and central a few miles west of Trebizond; almost exactly central at Bitlis and points to the southeast in Asiatic Turkey and Persia, where the eclipse ends at sunset in Sind, about 150 miles southeast of Hyderabad.

* For chart of this eclipse see page 33.

Meteorologically the outlook for successful observations of this eclipse is not especially encouraging. Doubtless if it happened earlier in the morning in Norway and Sweden, a clear totality would result; but coming in the afternoon, the likelihood of cloud is much greater. The region from Riga to the Crimea would seem to be far preferable; and here without doubt the bulk of the European and foreign parties will locate, many of them having preparations for observing the eclipse well advanced; in particular the English, French and Russian parties. Germany, Italy, Spain and Belgium will be well represented, as well as the United States, and Argentina.

In the region of Asiatic Turkey, the weather chances are considered very favorable, though the total eclipse is shorter there, about $2^m\ 3^s$, and the sun at a lower afternoon altitude. The high elevation of this territory will, however, fully compensate for this.

Farther historic interest attaches to the totality of 1914 from its connection with many earlier eclipses by the period of the Saros. If we go back six Saros periods, or 108 years, 2 months, we reach the totality of 1806, June 16, well observed in the eastern part of the United States. Total in a belt about 100 miles wide from California to New England, its duration then was more than double what it now is. Don Joaquin de Ferrer observed it total $4^m\ 37^s$ at New York, and DeWitt 14^s longer at Albany. Rutland, Vermont, on the north and Philadelphia on the south appear to have been just outside its limits of totality; and at Salem, Massachusetts, Bowditch, translator of the Mécanique Céleste, made excellent observations, even noting the corona, although at that early day few astronomers thought it was due to anything but what might naturally be expected from the powerful radiance of the sun glancing from the much inclined edge of the lunar disk interposed.

It was not indeed till the second following return of this eclipse, the 8th of July 1842, that the true nature of the corona was first made out; and this great eclipse, excellently observed in France, Italy, Germany and Russia by the great astronomers of that day—Airy, Arago, Baily, Littrow, Quetelet, Santini, Struve and many others—may be said to have laid the foundations of solar physics.

At the next return, July 18, 1860, the track lay on the American continent, and the first American expeditions were undertaken into British America and Labrador; but cloudy weather intercepted them. In Europe, however, a multitude of observers were highly successful; and the first fine photographs of the corona, by Secchi and De La Rue, proved the solar character of the corona beyond a doubt.

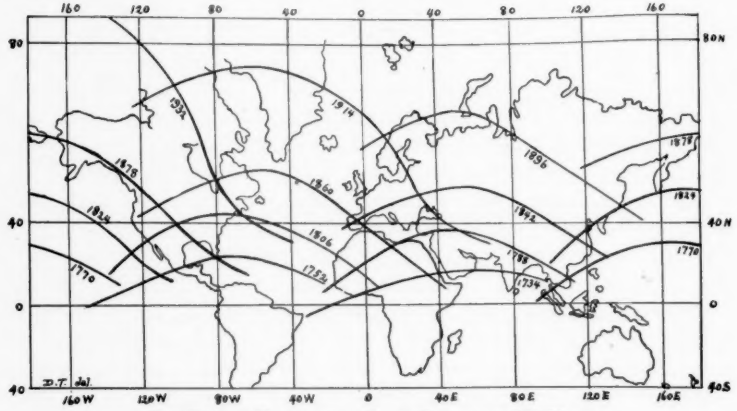
Especial American interest attaches to the next following return, July 29, 1878, because the track of this eclipse lay through the western United States, from Wyoming to Texas; and it was abundantly observed in

skies nearly everywhere clear, Langley from the summit of Pike's Peak discovering the long ecliptic streamers of the corona which were not successfully photographed till the India eclipse twenty years later.

On August 9, 1896, the last return, many parties stationed in Siberia and Japan failed because of cloud, while an English expedition in Nova Zembla was successful in photographing the spectrum of the reversing layer.

Recent progress in eclipse research has modified observers' programs very greatly. Simple contact observations are valuable, if the local time is accurately known, and longitude and latitude are well ascertained. We have no longer to follow up the supposed intramercurian planets, but can devote the more attention to detailed photography of the corona in every region. Its photometry is important and polariscopic observations also. There will be no opportunity to test any possible rapid changes in the corona, at say intervals of two or three hours, as the stations cannot be sufficiently widely separated. The spectroscope in a variety of forms will be applied to the corona itself, the possibility of its rotation with the sun, the flash spectrum not only in the mid-totality path but near its north and south margins, with a possibility of discovering new elements in the sun.

Farther interest attaches to this eclipse because it is almost the last of its Saros series. Originating at the south pole as a partial eclipse in the eleventh century, it first became a total eclipse on June 12, 1211, and passed the equator in the 17th century.



THE ECLIPSE TRACKS OF A SAROS GROUP FOR 200 YEARS.

The map shows very clearly the progression westward round the world with each Saros return, from May 3, 1734 (India) to August 31, 1932 (Labrador). Also the progression north poleward is well brought out,

each third return at 54-year intervals repeating in nearly the same longitude as before, but about 600 miles farther north on the planisphere of the projected earth. In a rough way, the general progression traces a sort of discontinuous spiral, winding northward round the earth with the lapse of time.

All solar eclipses may be classified as belonging to families progressing in this fashion. Of twelve such families, all the eclipses in six of them happen at the moon's descending node, and they progress northward; while the eclipses of the other six families take place at the ascending node, progressing southward.

The eclipse of 1914 is the 40th presentation of this totality, and the 41st will be visible in Maine August 31, 1932. Three additional returns, each farther north than the preceding one, and growing shorter and shorter, bring the final totality of the series: This will fall on October 3, 1986, in a tiny semi-circular track between Iceland and Greenland, the shortest of all the total eclipse tracks charted in Oppolzer's *Iconography*. Then after ten or eleven returns as a diminishing partial eclipse, this interesting series of obscurations will leave the earth's north pole, never to recur again.

Amherst, Nov. 22, 1913.

RADIAL VELOCITIES AND PREFERENTIAL MOTIONS.

R. H. CURTISS.

Probably no one will be misled by a statement by the writer appearing on page 609 of the December, 1913, number of POPULAR ASTRONOMY, in a review of Campbell's "*Stellar Motions*". This statement, referring to Campbell's study of extensive radial velocity data for evidences of preferential motion, applied only to the results described in the volume considered. It should have read:

"The results from 1193 objects could hardly be said, when considered together, to establish any real preferential tendencies."

As the sentence appeared, the word "indicate" replaced "establish." My letter of November 23, to the Editor of POPULAR ASTRONOMY, asking that this slip in my manuscript be corrected, arrived before the article was issued but too late for the insertion of the proper word.

The results of Campbell's study of the radial velocities of 1193 objects, even when all these objects are considered as a whole, do furnish some indication of preferential tendencies in stellar motions. Uncertainty arises, however, because of the small differences in velocity upon which

the evidence rests, and because of the heterogeneous character of the data. Uncertainty is indicated by the changes in the results, large in proportion to the effect observed, which resulted from the addition of 159 objects to the original list of 1034. And the cause of a part of this indicated uncertainty is suggested by the circumstance that the changes noted followed the inclusion of a group of stars comprising a greater proportion of earlier spectral type having relatively lower average velocities.

The conviction arises at once that, in seeking evidences of preferential stellar motions through radial velocities, the objects included might well be considered by spectral classes. Such studies of indications of preferential motion have been carried on by Professor Campbell and have led to very interesting results, accessible in the *Lick Observatory Bulletins* to those who are interested in the details. Campbell's estimates of the meaning of these results are of especial value since they convey a good idea of the present status of the problem. It should be remembered that the studies considered involved the application of this principle: If the stars seen in projection upon the various large areas of the sphere have in reality equal average velocities *in space*, but with proper motion preferences for Kapteyn's two vertices of preferential motion, the residual radial velocities of the stars seen in projection near these vertices should on the average be greater than for the stars in the zone midway between these vertices. The more important of Campbell's estimates of the results of these studies may well be quoted in one place with explanatory parenthetical insertions:

Lick Observatory Bulletin, 196, p. 130; also "*Stellar Motions*" Chapter VI, p. 218. "The indications for preferential velocities (1034 objects) toward and from the vertices are therefore fairly clear; but quantitively the preference is very much smaller than we were expecting to find, in view of the proper motion results."

L. O. B. 196, p. 130. "Indications for preferential velocities (1193 objects) to and from the vertex are not so strong as those presented in the Silliman lecture (1034 objects)."

Stellar Motions, Chapter VI, p. 219. "We have therefore a tolerably clear and strong indication that the high velocity stars have a preference for motion toward the Kapteyn vertices."

L.O.B. 195, p. 117. "Therefore this evidence (177 B-type stars) is not in support of preferential motion in the Class B stars with reference to the assumed vertices."

L. O. B. 195, p. 119. "It is thus clear that the (270) Class B stars upon which the present investigation is based lend no support to the hypothesis of preferential motion toward and from the assumed vertices."

L. O. B. 211, 29. "The tabulation of the 1911 Class A results seemed to show that the stellar velocities are functions of galactic latitudes as well as of angular distances from the Kapteyn vertices. The results for the greater number of 1912

Class A stars seem to show a smaller dependence of radial velocities upon galactic latitudes, and to reduce in amount their apparent dependence upon distances from the Kapteyn vertices."

"...The preferential motion effect is apparently stronger for Class A stars than for stars of classes F, G, K and M."

Kapteyn, in an address of last April before the National Academy of Sciences, speaks quite confidently of the favorable character of the radial velocity evidence bearing upon preferential stellar motion. He says, undoubtedly with recent Mount Wilson observations also in mind:

"We may say that all investigations made since the first announcement of star streaming in 1904...agree in the establishment of these two preferential directions of motion among the stars...They betray their existence in the radial motions as well as in the motion at right angles to the visual ray."

But the radial velocity observations have gone farther than this. They were used by Plummer in a study which led to a suggestion to the effect that the Class A stars were not well represented in the second of the two great star streams. As Kapteyn expresses it, the older the stars, the richer the second stream, at least in comparison with the first stream. Researches of Kapteyn and others leave little doubt as to the reality of this phenomenon, announced by Kapteyn at Groningen in 1911.

Kapteyn also calls attention to the deduction that observations show, contrary to what takes place with the internal motion, that the relative velocity of the two streams or clouds of stars does not change, or does not change very much, with supposed stellar age.

Reasoning chiefly from these points, Kapteyn considers that the conclusion to be drawn seems obvious, namely, that we are driven to the theory of the two-star clouds which, owing to their initial velocity, have come to meet and intermingle in space. But, in his opinion, it seems best, for the present, to put the theory forward as the hypothesis which best satisfies the observed facts. Thus a conception which many have been considered merely as a hypothetical help to the imagination is now advanced as a hypothesis by one eminently fitted to judge. All will await with interest the further test of observation in connection with this striking proposal.

1913, Dec. 5.

SIR ROBERT BALL.

HECTOR MACPHERSON, Jr.

The death of Sir Robert Ball which took place at Cambridge, England, on November 25 removes one of the most popular of modern astronomers and one whose place will be difficult to fill.

Robert Stawell Ball was a native of Dublin, where he was born on July 1, 1840, and where his father, Dr. Robert Ball, was a well-known naturalist. He received his early education in England—at Chester—and afterwards at Trinity College, Dublin. In early manhood, he became devoted to astronomy and in 1865 received his first appointment—that of astronomer to the Earl of Rosse at Birr Castle, Parsontown, Ireland, where the great six-foot reflector had been erected twenty years earlier. For two seasons he worked at Parsontown and he had the good fortune to witness the great shower of meteors—the Leonids—on November 13-14, 1866. He left Lord Rosse's Observatory to occupy the chair of Applied Mathematics and Mechanics in the Royal College of Science for Ireland—a position which he held until 1874, when he was selected as Andrews Professor of Astronomy in Dublin University and Royal Astronomer for Ireland, which carried with it the directorship of the Dunsink Observatory. Ball worked in Dublin for eighteen years; and indeed his most important original work was accomplished there. In the same year—1874—he commenced his career as a public lecturer on astronomy; and in 1886 he received the honor of knighthood.

In 1892 Sir Robert Ball was elected to the Lowndean Professorship of astronomy at Cambridge, in succession to Adams, the discoverer of Neptune, and this post he held until his death. He continued as an active lecturer and author on astronomy till within a few years of his death, when he abandoned public lecturing, and practically retired from active work on account of failing health.

Sir Robert Ball's services to astronomy were of two kinds. He was (i) an original investigator and (ii) a popular writer and lecturer. In both spheres he achieved distinction.

(i) His original work was chiefly accomplished while he was director of Dunsink Observatory and Royal Astronomer of Ireland. In 1876 he made a particular study of the new star in Cygnus, discovered on November 24 of that year by Schmidt of Athens. He made a series of measurements with a view to ascertaining the parallax of the star and as a result found only a negative value; so as a minimum estimate he

was able to state that the star was at least 20,000,000,000,000 miles from the solar system. In 1881 he commenced a systematic search for stars with large parallaxes. He studied 450 stars and of these only one —1618 Groombridge—proved to be within measurable distance. In 1878 and 1884 he remeasured the parallax of 61 Cygni, confirming the value deduced by Otto Struve.

Ball was a mathematician of considerable power; for 25 years he grappled with the "Theory of Screws." The results of his investigation were summarized in memoirs communicated to the Royal Irish Academy from 1872 to 1897.

(ii) In 1886 Ball's career as an independent investigator in astronomy practically came to an end. He published in that year "The Story of the Heavens" and commenced his career as a popular writer on the subject. In a sense, this is to be regretted. He had ability as an original student of astronomy and he might have made further contributions to the purely scientific side of the subject. However, he chose another part and in the role of popular lecturer and writer he achieved distinction of no mean order.

He was a prolific writer: his earliest work was "The Elements of Astronomy" published in 1880. This was followed by "The Story of the Heavens" which made his name as a popular writer. It appeared in 1886 and entered a second edition in 1900. It is a popular book, but on a large scale, written in a clear and forcible style. In 1889 he published his popular work "Star Land," designed for young people, but perfectly suitable for beginners of all ages; and in the same year "Time and Tide" appeared.

After his appointment to Cambridge, Ball published a number of books in rapid succession. "In Starry Realms" and "An Atlas of Astronomy" appeared in 1892; and in the following year "The Story of the Sun" was published. It is less popular than his other works, for it is a large book and deals with aspects of solar astronomy which do not appeal to the amateur star-gazer. In 1894 he published "In the High Heavens" and in 1895 "Great Astronomers." In this book he sketched the lives of famous students of the heavens from Hipparchus to the present time. Unfortunately the usefulness of this otherwise admirable volume is impaired by the sentimental partiality of Sir Robert Ball's selection of astronomers. The inclusion for instance of Sir William Rowan Hamilton—an Irishman, but not an astronomer in the real sense of the word—of Brinkley, first Royal Astronomer of Ireland and of the Earl of Rosse, and the exclusion of such masters as Huyghens, Olbers and Bessel does much to lessen the value of a volume written in Sir Robert's finest style.

In 1900 "A Primer of Astronomy" appeared, and it was followed in

1901 by "The Earth's Beginning" based on a course of lectures on the Nebular Theory, and a few years later by a volume on "Spherical Astronomy."

Of the various books which issued from his facile pen, "The Story of the Heavens" was the most elaborate and "Star-Land" the most popular; but to the serious student "Time and Tide" and "The Earth's Beginning" were his greatest books. Ball was at his best when expounding and defending a hypothesis. In "Time and Tide" he gave a popular exposition of Darwin's theory of tidal friction and in "The Earth's beginning" he gave the most readable *resumé* of the general theory of the earth's development from nebulous matter. In this book he did not merely expound other men's views. He showed forth his own version of the Nebular Theory, making his own suggestions and modifications.

Sir Robert Ball's career as a public lecturer began in 1874 and ended only a year or two before his death. He lectured on various occasions before the Royal Institution in London; he visited the United States and Canada. In addition he travelled practically all over the United Kingdom. It has been truly said of him that "There is no important town in England, Scotland, Ireland or Wales where Sir Robert Ball has not lectured and in most cases lectured often. At a very modest estimate over one million people have heard him lecture?

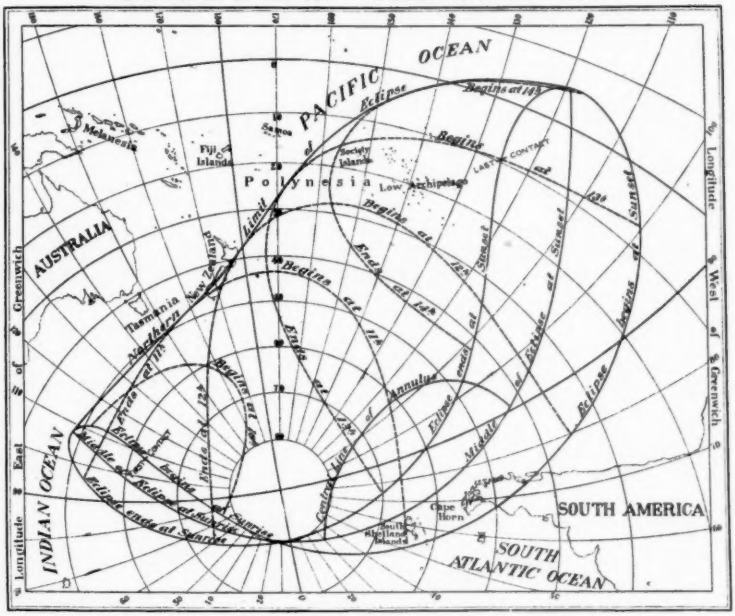
It was his peculiar function, then, to impart to the amateur and to the unlearned listener the wonders and mysteries of astronomy; and he certainly succeeded in making his science popular. Thus his death is mourned by a wider circle than those of greater and less popular men. Largely as a result of his own deliberate choice, Ball will not go down to posterity as a great student like Huggins or Schiaparelli or Vogel; but he will long be remembered as the expounder of the science to the unlearned, and many an astronomer owes his first interest in his science to the popularizing work of the genial Irishman who has passed into the great Beyond. Astronomy needs both its students and its popularisers. Science has a duty to the mass of mankind: and this duty some one must perform. In this sphere Sir Robert Ball nobly performed the task which he set himself.

ASTRONOMICAL PHENOMENA IN 1914.

ECLIPSES.

In the year 1914 there will be four eclipses, two of the sun and two of the moon. The most interesting one will be the total eclipse of the sun on August 20-21. Unfortunately for Americans the path of totality does not cross our continent except in the extreme northern part of Greenland, and we shall not have the privilege of witnessing this interesting and unusual phenomenon. As may be seen from the accompanying diagram the path of totality starts among the islands of the Arctic

ANNULAR ECLIPSE OF FEBRUARY 24TH 1914.



Note *The hours of beginning and ending are expressed in Greenwich Mean Time.*

Ocean crosses Greenland and the North Atlantic Ocean, thence passes across Norway and Sweden and southeast through Russia, across the Black Sea, ending in southern Asia. As is customary in the case of a total eclipse, astronomical expeditions will be sent from many of the large observatories of the world to points along the path of totality where the probabilities of clear skies are most favorable. The regions best suited in this case will be along the path in southern Russia.

The other eclipse of the sun will be an annular eclipse on February 24. The only land from which this will be visible is the extreme southern part of South America and some of the islands in the southern Pacific Ocean.

The eclipses of the moon will both be partial.

The following data concerning the eclipses of this year are taken from the *American Ephemeris* for 1914.

I. *An Annular Eclipse of the Sun*, 1914, February 24, invisible at Washington.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension, February $^{d}24\ ^{h}11\ ^{m}15\ ^{s}53.9$

Sun and Moon's R. A.	$^{h}22\ ^{m}29\ ^{s}20.02$		Hourly motions	$^{s}9.49$ and	$^{s}110.05$
	° ′ ″			′	″
Sun's declination	9 29 28.8	S.	Hourly motion	0	55.4 N.
Moon's declination	10 27 8.2	S.	Hourly motion	13	38.5 N.
Sun's equa. hor. parallax	8.9		Sun's true semidiameter	16	9.3
Moon's equa. hor. parallax	54 35.3		Moon's true semidiameter	14	51.8

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time.	Longitude from Greenwich.	Latitude.
	d h m	° ′	° ′
Eclipse begins	Feb. 24 9 45.6	108 1.1 E.	62 41.7 S.
Central eclipse begins	24 11 34.5	30 54.6 W.	77 35.0 S.
Central eclipse at noon	.. ..	.. ...	.. ...
Central eclipse ends	24 12 51.8	90 41.5 W.	42 51.2 S.
Eclipse ends	24 14 40.4	125 10.0 W.	9 33.5 S.

II.—*A Partial Eclipse of the Moon*, 1914, March 11, visible at Washington the beginning visible generally in Europe, Africa, and North and South America; the ending visible generally in western Europe, western Africa, North and South America, and throughout the Central and eastern portions of the Pacific Ocean.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of opposition in right ascension, March $^{d}11\ ^{h}16\ ^{m}42\ ^{s}51.9$

Sun's right ascension	$^{h}23\ ^{m}26\ ^{s}6.49$		Hourly motion		$^{s}9.19$
Moon's right ascension	11 26 6.49		Hourly motion		133.65
	° ′ ″			′	″
Sun's declination	3 39 27.0	S.	Hourly motion	0	58.9 N.
Moon's declination	3 2 44.3	N.	Hourly motion	18	4.5 S.
Sun's equa. hor. parallax	8.9		Sun's true semidiameter	16	5.6
Moon's equa. hor. parallax	61 11.4		Moon's true semidiameter	16	39.6

CIRCUMSTANCES OF THE ECLIPSE.

	d h m	
Moon enters penumbra	March 11 13 40.7	Greenwich Mean Time.
Moon enters shadow	11 14 41.8	
Middle of the eclipse	11 16 12.9	
Moon leaves shadow	11 17 44.0	
Moon leaves penumbra	11 18 45.1	

Contacts of Shadow with Moon's limb.	Angles of position from the north point.	The Moon being in the zenith in longitude from Greenwich.	and in latitude.
	°	° ′	° ′
First	88 to E.	38 58 W.	3 39 N.
Last	30 to W.	82 56 W.	2 44 N.

Magnitude of the eclipse = 0.916 (Moon's diameter = 1.0).

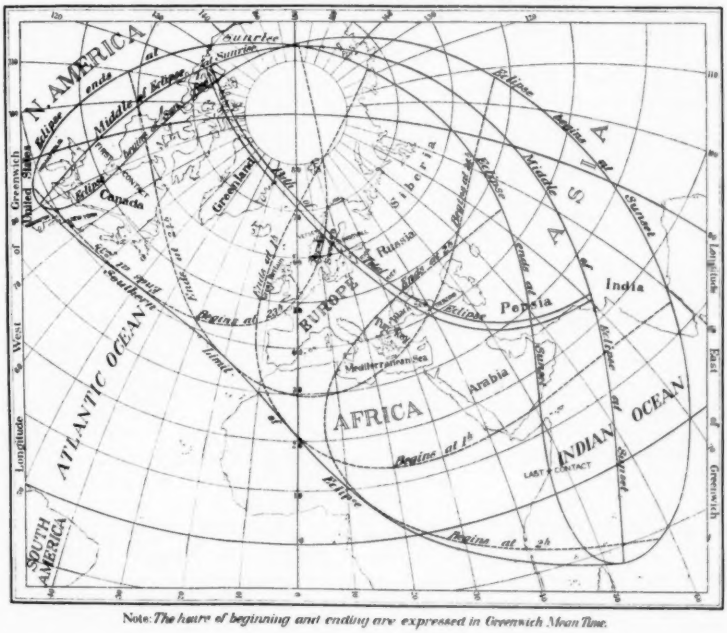
III. *A Total Eclipse of the Sun*, 1914, August 20-21, Washington being just within the eclipse limits.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension, August 20 23 54 55.2 (d h m s)

Sun and Moon's R.A.	9 59 2.34 (h m s)		Hourly motions	9.26 and 132.48 (s s)	
Sun's declination	12 19 29.6 N. (° ′ ″)		Hourly motion	0 49.7 S. (′ ″)	
Moon's declination	13 9 44.3 N.		Hourly motion	15 15.9 S.	
Sun's equa. hor. parallax	8.7		Sun's true semidiameter	15 48.7	
Moon's equa hor. parallax	59 17.9		Moon's true semidiameter	16 8.7	

TOTAL ECLIPSE OF AUGUST 20TH–21ST, 1914.



Note: *The hours of beginning and ending are expressed in Greenwich Mean Time.*

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time. (d h m)	Longitude from Greenwich. (° ′)	Latitude. (° ′)
Eclipse begins	Aug. 20 22 12.0	79 36.3 W.	53 49.6 N.
Central eclipse begins	20 23 26.1	121 11.9 W.	71 23.4 N.
Central eclipse at noon	20 23 54.9	2 4.2 E.	70 52.5 N.
Central eclipse ends	21 1 42.8	70 35.8 E.	23 44.7 N.
Eclipse ends	21 2 56.7	47 28.3 E.	3 57.2 N.

IV. *A Partial Eclipse of the Moon*, 1914, September 3-4, invisible at Washington; the beginning visible generally in western North America, the Pacific Ocean, eastern Asia, Australia, and Oceanica; the ending visible generally in the central and western portions of the Pacific Ocean, Asia, Australia, the Indian Ocean, and the extreme east of Africa.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of opposition in right ascension, September $4^{d}\ 2^{h}\ 27^{m}\ 25^{s}.0$

	h m s		s
Sun's right ascension	10 50 36.77	Hourly motion	9.04
Moon's right ascension	22 50 36.77	Hourly motion	110.64
	° ′ ″		′ ″
Sun's declination	7 22 13.0 N.	Hourly motion	0 55.2 S.
Moon's declination	6 49 4.8 S.	Hourly motion	14 20.9 N.
Sun's equa. hor. parallax	8.7	Sun's true semidiameter	15 51.8
Moon's equa. hor. parallax	55 12.9	Moon's true semidiameter	15 2.0

CIRCUMSTANCES OF THE ECLIPSE.

	d h m	
Moon enters penumbra	Sept. 3 23 1.3	Greenwich Mean Time.
Moon enters shadow	4 0 16.3	
Middle of the eclipse	4 1 54.7	
Moon leaves shadow	4 3 33.1	
Moon leaves penumbra	4 4 48.1	

Contacts of Shadow with Moon's limb.	Angles of position from the north point.	The Moon being in the zenith in longitude from Greenwich.	and in latitude.
	°	° ′	° ′
First	94 to E.	174 47 E.	7 20 S.
Last	150 to W.	126 58 E.	6 33 S.

Magnitude of the eclipse = 0.864 (Moon's diameter = 1.0).

The regions within which the eclipses of the sun are visible are laid down on the accompanying charts, from which, by means of the dotted lines, the Greenwich mean time of beginning and ending at any place may be found with an uncertainty which will vary from three or four minutes for a high sun to fifteen or twenty minutes when the sun is near the horizon.

TRANSIT OF MERCURY

A Transit of Mercury over the Sun's Disk, will take place 1914, November 6-7, partly visible at Washington, the sun rising with Mercury on its Disk. The ingress will be visiblegenerally in western Australia, central and western Asia, Europe, Africa, and in South America, excepting the northwestern portion; the egress in southwest Europe, Africa, South America, and in North America, excepting the northwestern portion.

ELEMENTS OF THE TRANSIT.

Greenwich mean time of conjunction in right ascension, November $6^{d}\ 23^{h}\ 11^{m}\ 38^{s}.7$

	h m s		s s
Sun and Mercury's R.A.	14 46 58.14	Hourly motions +9.98 and −12.09	
	° ′ ″		′ ″
Sun's declination	16 6 37.7 S.	Hourly motion	0 44.7 S.
Mercury's declination	16 18 18.0 S.	Hourly motion	1 48.4 N.
Sun's equa. hor. parallax	8.88	Sun's true semidiameter	16 8.58
Mercury's equa. hor. parallax	13.04	Mercury's true semidiameter	4.95

GREENWICH MEAN TIME OF THE GEOCENTRIC PHASES.

		d	h	m	s
Ingress, exterior contact	November	6	21	57	14.2
Ingress, interior contact		6	21	59	27.3
Least distance of centers, 10′ 30″.9		7	0	3	20.4
Egress, interior contact		7	2	7	17.5
Egress, exterior contact		7	2	9	30.8

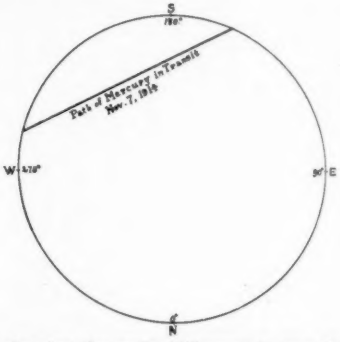


FIG. 3. Diagram showing the path of Mercury in transit across the Solar disk, November 7, 1914, as seen from the center of the earth.

CIRCUMSTANCES OF THE TRANSIT.

	Angles of position from the north point	Mercury being in the astronomical zenith in longitude from Greenwich	and in latitude.
	° ′	° ′	° ′
Ingress, exterior contact	158 7 E.	26 44 E.	16 21 S.
Ingress, interior contact	156 37 E.	26 11 E.	16 20 S.
Least distance of centers		4 59 W.	16 17 S.
Egress, interior contact	105 10 W.	36 10 W.	16 13 S.
Egress, exterior contact	104 40 W.	36 43 W.	16 13 S.

The Greenwich mean times of the four contacts for any point on the surface of the earth may be computed from the four following formulæ, respectively, in which ρ denotes the radius of the earth at that point, ϕ' the geocentric north latitude, and λ the longitude *west* from Greenwich. The numbers in brackets are the logarithms of the respective coefficients.

h m s ° ′

Ing. ext. $T^1 = 21\ 57\ 14.2 + [1.6875]\ \rho \sin \phi' - [1.4317]\ \rho \cos \phi' \cos (209\ 53.3 - \lambda)$
Ing. int. $T^2 = 21\ 59\ 27.3 + [1.6925]\ \rho \sin \phi' - [1.4294]\ \rho \cos \phi' \cos (209\ 49.7 - \lambda)$
Eg. int. $T^3 = 2\ 7\ 17.5 - [1.1426]\ \rho \sin \phi' + [1.7346]\ \rho \cos \phi' \cos (131\ 2.8 - \lambda)$
Eg. ext. $T^4 = 2\ 9\ 30.8 - [1.1248]\ \rho \sin \phi' + [1.7322][\rho \cos \phi' \cos (131\ 27.5 - \lambda)$

THE PLANETS.

The charts, Figs. 4 and 5, are designed to show the paths of the various planets throughout the year. The movements of all the planets around the sun are continuous, but since their apparent courses are the result of the combined motions of the planets themselves and that of the earth, the paths are seen to take peculiar shapes at certain times during the year.

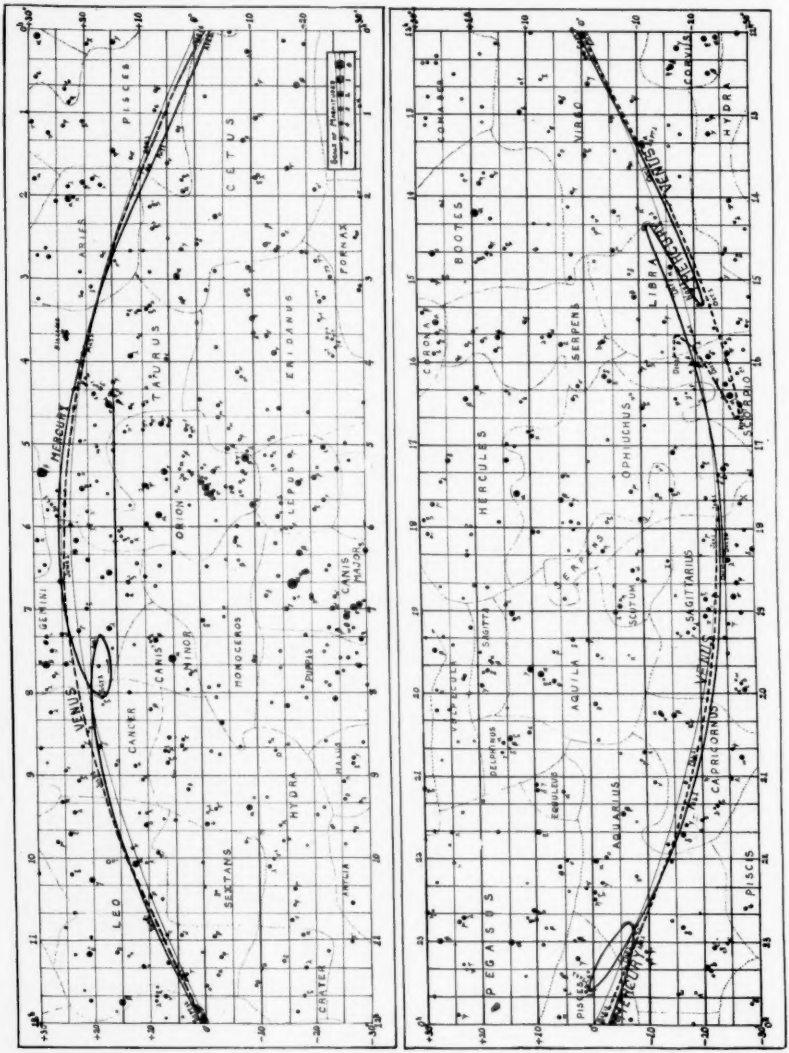


FIG. 4. Apparent paths of the planets Mercury and Venus among the stars during the year 1914.

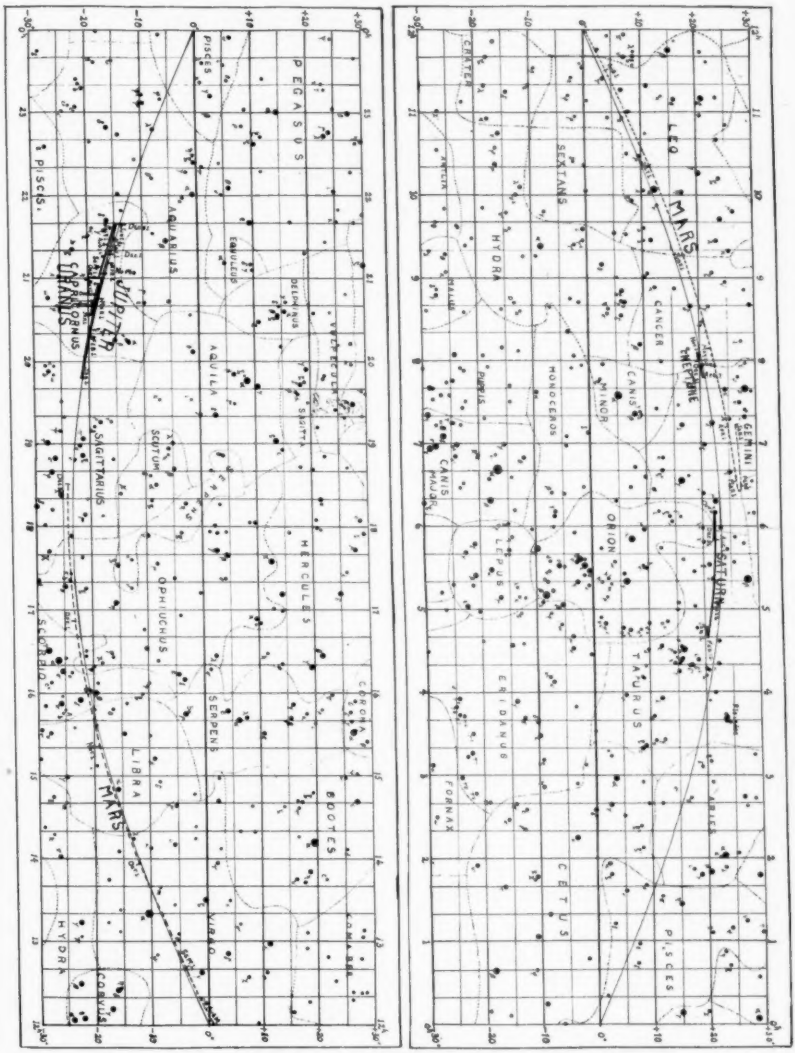


FIG. 5. Apparent paths of the planets Mars, Jupiter, Saturn, Uranus and Neptune among the stars during the year 1914.

These charts may be used to identify the planets, especially those which are visible to the naked eye. Any planet can be located on its path at any given date, then by noting the configurations of the stars in that region the planet can be detected. Of course one must have some knowledge of the constellations or some idea of right ascension or he will not know in which part of the sky to look for the planets. An idea of right ascension positions may be obtained by noting that the sun is in a position of zero right ascension on March 22 and that it increases two hours each month.

Mercury, which is traveling in the smallest orbit of all the planets, never gets very far away from the sun and consequently follows the sun in its course around the sky during the year. At the beginning of the year it is found in the constellation *Ophiuchus* and is moving eastward. At the end of the year it is found in the constellation *Sagittarius* nearly an hour in right ascension to the east of its position at the beginning of the year. In the latter part of February and March it describes an almost perfect elliptical course in *Pisces* and *Aquarius*. It then proceeds toward the east until July 1, when it again begins a loop in the eastern part of *Gemini*. After August 1 it again moves eastward until the latter part of October, when it begins a zigzag path in *Libra*. After this it continues eastward to the end of the year.

It may be seen in the west just after sunset on and near the following dates: February 22, June 18, October 14; and in the east just before sunrise on and near the following dates: April 6, August 4 and November 23. Throughout the rest of the year it will be too near the sun to be visible.

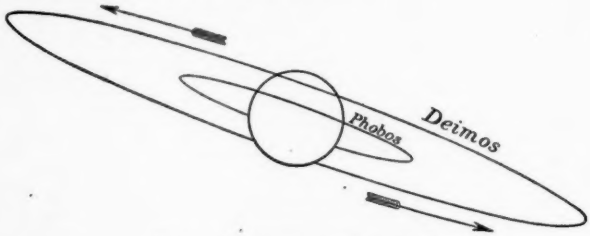


FIG. 6. SATELLITES OF MARS, 1914.
Apparent orbits of the satellites of Mars at date of opposition, January 5, 1914, as seen in an inverting telescope.

Venus is seen by the dotted line in Figure 4 to be quite near to *Mercury* at the beginning of the year. It ends the year on the border line between *Libra* and *Scorpio*, about two hours west of its starting point. It therefore does not complete an entire circuit around the sky. It proceeds continuously toward the east from January 1 to November 1, from which time until the end of the year it describes a zigzag path in *Scorpio and Libra*. On January 1 it is a short distance west of the sun and is hardly visible. It is moving toward the sun and on February 11 passes on the opposite side of the sun from the earth. Soon thereafter it becomes visible in the evening sky and in the latter part of the summer it becomes the brilliant evening star. It reaches its greatest distance east of the sun on September 17 and will then be an exceedingly bright object, rather high in the sky at sunset. It then moves toward the sun and passes between the earth and the sun on November 27. Before the end of the year it will again become visible as the morning star.

Mars begins the year with a retrograde motion in the constellations *Gemini*. It continues to move westward until the middle of February, after which time it

moves eastward continuously throughout the year. It ends the year in the constellation *Sagittarius* too near the sun to be visible. It will be in fairly good position for observation during nearly all of the year. It is in opposition early in January, but is not so near at that time as it is at the most favorable oppositions.

Figure 6 shows the orbits of its satellites, Phobos and Deimos. These do not possess such great general interest because they are accessible only to those observers having large telescopes at their disposal.

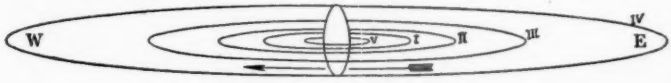


FIG. 7. SATELLITES OF JUPITER, 1914.
Apparent orbits of the five inner satellites of Jupiter at date of opposition, August 10, 1914, as seen in an inverting telescope.

Jupiter on January 1 is in the eastern part of the constellation *Sagittarius* and moves eastward into *Capricornus*. From June 1 to October 1 it has a retrograde motion, after which it returns so nearly along the same path that on the scale of the diagram it is not possible to distinguish the two. It will be too close to the sun to be observed during the first two months. After that it will be visible in the morning sky and will rise earlier each day, so that by the latter part of the summer it will be visible in the evening. Unfortunately for northern observers it will remain rather far south throughout the year. The orbits of five of its satellites are shown in Figure 7.

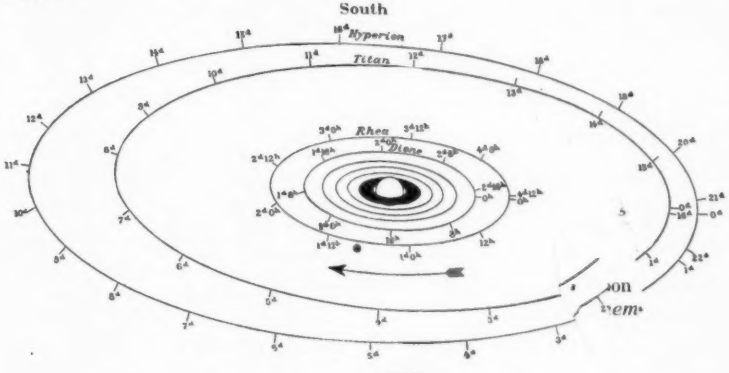


FIG. 8. SATELLITES OF SATURN, 1914.
Apparent orbits of the seven inner satellites of Saturn at date of opposition, December 20, 1914, as seen in an inverting telescope.

Saturn moves from *Taurus* into *Gemini* and then returns into *Taurus*. Its motion is westward during the first month and during the last two and a half months. It will be visible in the evening until about May 1; then will be invisible for about two months while the sun is passing it. It will be in conjunction on June 12. About a month after this date it will again become visible in the eastern sky in the early morning. It will be at opposition in December and will rise then at sunset. Figure 8 shows the apparent orbits of the seven inner satellites and the general appearance of the rings.

Uranus describes a short path near the orbit of Jupiter in the constellation *Capricornus*. At the end of the year it is only about five degrees east of its position at the beginning. Its motion from May to October is retrograde. It like Jupiter is so far south as to be unfavorably situated for observation from northern locations. Moreover, it requires a good sized telescope to see any markings on the planet. The orbits of its satellites are shown in Figure 9.

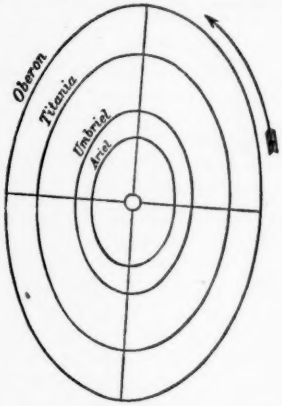


FIG. 9. SATELLITES OF URANUS, 1914. Apparent orbits of the satellites of Uranus at date of opposition, August 2, 1914, as seen in an inverting telescope.

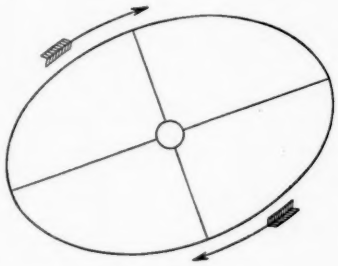


FIG. 10. SATELLITE OF NEPTUNE, 1914. Apparent orbit of the satellite of Neptune at date of opposition, January 17, 1914, as seen in an inverting telescope.

Neptune moves back and forth in the constellations *Gemini* and *Cancer*. Its position at the end of the year differs very slightly from that at the beginning. It begins and ends the year with retrograde motion. It traverses nearly its entire path twice. It will be very near the sun during July and August but will be visible during the rest of the year, being at opposition on January 17. Figure 10 shows the orbit of its only satellite. The planet is not easy to observe with a small telescope as it is difficult to distinguish between it and a star.

COMETS.

Of the comets discovered during 1913, Metcalf's comet *b* should still be visible, but only with very powerful telescopes; Westphal's periodic comet should be visible had it not in some unaccountable way lost most of its light, so that for the past two months it has been practically invisible; Giacobini's periodic comet, rediscovered by Zinner October 23, 1913, will be visible to observers in the southern hemisphere for a month or two yet.

Of periodic comets which may be expected to return to perihelion in 1914 only two are sure, Tempel-Swift and Encke's.

1. Comet Tempel-Swift is due at perihelion about June 7. At that time the comet will be almost behind the sun so that it cannot be seen. It may possibly be picked up in the spring before it comes to perihelion.

2. Encke's comet is due at perihelion about December 4. It will be nearest the earth in October and will doubtless be observed long before that.

3. Brooks' comet 1886 IV, if its period has not changed, should come to perihelion about the last of May, under much the same conditions as in 1886. It has not been seen since 1886, so that its present orbit is very uncertain. The calculated period was 5.595 years.

METEORS.

The appearance of a meteor, especially a brilliant one, always comes as a surprise because its coming cannot be predicted. Coming thus suddenly and unexpectedly one is apt to conclude that they come entirely at random. Such is not the case, as many belong to definite groups and the times when they, as a group, will appear can be predicted.

The following list is taken from Mr. W. F. Denning's list in the *Companion to the Observatory* for 1913. It may be found useful in classifying the meteors that may be observed during the year.

Date	Radiant α	Radiant δ	Meteors
Jan. 2-3	230°	+53°	Swift; long paths.
Apr. 20-22	271	+33	Swift.
May 1-6	338	— 2	Swift; streaks.
July 28-30	339	—11	Slow; long.
Aug. 10-13	46	+57	Swift; streaks.
Oct. 18-20	92	+15	Swift; streaks.
Nov. 14-16	150	+22	Swift; streaks.
Nov. 17-23	25	+43	Very slow; trains.
Dec. 10-12	108	+33	Swift; short.

The Perseids may be seen through the period from July 19 to August 16, having a maximum on August 11, at which date the radiant will be in position, $\alpha = 45°$, $\delta = +57°$.

VARIABLE STARS.

The table of times of minima of a list of short period variables, and of times of maxima of another list, will be continued throughout the year. The positions and elements of these stars have been carefully revised and the published times are those in accordance with the latest elements available.

The table of "Approximate Magnitudes of Variable stars of Long Period" will be prepared as formerly at the Harvard College Observatory, through the courtesy of Professor Pickering.

OCCULTATIONS.

The list of bright stars which are to be occulted by the moon will be given month by month. This list will be taken from the *American Ephemeris*.

PLANET NOTES FOR FEBRUARY, 1914.

The sun will move northward more than 14 degrees during the month and by the end will be a little more than eight degrees south of the equator. It will move eastward from the constellation Capricornus into Aquarius.

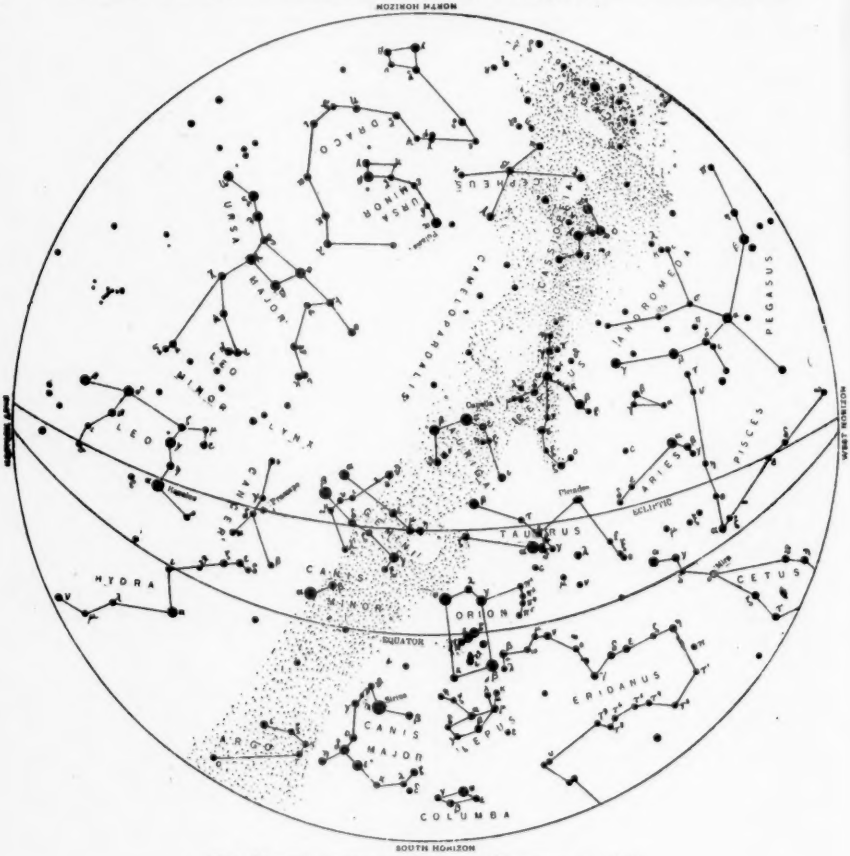
The phases of the moon for this month are as follows:

First Quarter	Feb. 3	at	5 A.M.	C. S. T.
Full Moon	10	"	12 M.	"
Last Quarter	17	"	3 A.M.	"
New Moon	24	"	6 P.M.	"

Mercury will reach a point of greatest eastern elongation on February 22. At that time it will be several degrees north of the sun also and will be in a fairly good position for observation. It will be visible in the western sky just after sunset.

Venus will be moving eastward a little more rapidly than the sun. It will be too close to the sun throughout the month to be visible. It will pass the sun on the opposite side from the earth on February 11.

Mars will move westward slowly during the first part of the month. It will



THE CONSTELLATIONS AT 9:00 P. M. FEBRUARY 1, 1914.

become stationary on February 12, after which it will begin to move slowly eastward. It will be favorably situated for observation, as it will be quite a distance above the eastern horizon at sunset at the end of the month.

Jupiter will still be quite close to the sun at the beginning of the month. By the end of the month it will again become visible just before sunrise. It will be moving northward and will therefore be coming into better position for northern observers.

Saturn will change its position very little during the month. It will be moving westward at the beginning of the month, but will become stationary on February 11. After this date it will move eastward and be in almost the same position at the end as it was at the beginning. It will be visible in the evening throughout the month. By the end of the month it will be very near the meridian at sunset.

Uranus will be too near the sun for observation during the month.

Neptune will be almost directly south of Castor and Pollux. It will be easily accessible in the east in the evening throughout the month.

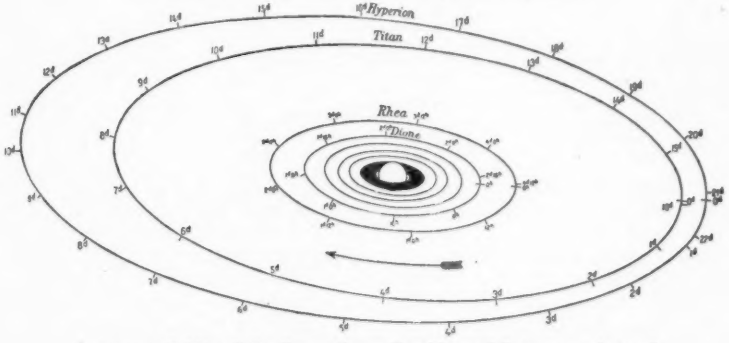
Occultations Visible at Washington.

Date 1914	Star's Name	Magnitude	IMMERSION. Washington M.T.		Angle from N.	EMERSION. Washington M.T.		Angle from N	Duration	
			h	m	°	h	m	°	h	m
Feb. 5	38 B Aurigae	6.5	8	29	143	9	15	206	0	46
5	47 B Aurigae	6.0	11	18	66	12	21	301	1	3
7	47 Geminorum	5.6	11	4	82	12	13	315	1	9
8	35 B Cancri	6.4	12	20	174	13	0	239	0	40
9	12 B Leonis	6.3	18	43	155	19	20	255	0	37
11	c Leonis	5.1	10	4	160	10	57	266	0	54
12	9 B Virginis	6.2	7	45	152	8	29	264	0	43
13	ψ Virginis	5.0	15	5	149	16	15	291	1	10
17	135 B Scorpii	6.0	16	6	130	17	18	267	1	12

Saturn's Satellites for February, 1914.

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.



Apparent Orbits of the Seven Inner Satellites of Saturn, at date of Opposition, December 6, 1913, as seen in an Inverting Telescope.

I. Mimas. Period $0^d\ 22^h.6$

	h		h		h		h	
Feb. 1	11.5 E	Feb. 5	6.0 E	Feb. 10	10.3 W	Feb. 13	6.2 W
2	10.1 E	8	13.1 W	11	8.9 W	17	12.0 E
3	8.7 E	9	11.7 W	12	7.5 E	18	10.6 E
4	7.3 E						

II. Enceladus. Period $1^d\ 8^h.9$ ●

Feb. 2	5.5 E	Feb. 9	2.0 E	Feb. 15	22.4 E	Feb. 22	18.9 E
3	14.4 E	10	10.9 E	17	7.3 E	24	5.7 E
4	23.3 E	11	19.7 E	18	16.2 E	25	12.6 E
6	8.2 E	13	4.6 E	20	1.1 E	26	21.4 E
7	17.1 E	14	13.5 E	21	10.0 E	28	6.4 E

III. Tethys. Period $1^d\ 21^h.3$

Feb. 2	19.8 E	Feb. 10	9.0 E	Feb. 17	22.3 E	Feb. 23	14.2 E
4	17.1 E	12	6.3 E	19	19.6 E	25	11.5 E
6	14.4 E	14	3.6 E	21	16.9 E	27	8.8 E
8	11.7 E	16	0.9 E				

IV. Dione. Period $2^d\ 17^h.7$

Feb. 0	23.1 E	Feb. 9	4.1 E	Feb. 17	9.2 E	Feb. 25	14.3 E
3	16.7 E	11	21.8 E	20	2.9 E	28	8.0 E
6	10.4 E	14	15.5 E	22	20.6 E		

V. Rhea. Period $4^d\ 12^h.5$

Feb. 1	23.3 E	Feb. 11	0.1 E	Feb. 20	1.0 E	Feb. 24	13.5 E
6	11.7 E	15	12.6 E				

VI. Titan. Period $15^d\ 23^h.3$

Feb. 1	8.7 E	Feb. 9	4.0 W	Feb. 17	5.5 E	Feb. 25	3.0 S
5	7.6 I	13	2.6 S	21	6.4 I		

VII. Hyperion. Period $21^d\ 7^h.6$

Feb.	3.4 E	Feb.	13.9 W	Feb.	19.9 S	Feb.	24.7 S
	8.1 I						

VIII. Japetus. Period $79^d\ 22^h.1$

Feb. 12.6 S

IX. Phoebe. Period $580^d\ 2^h.9$

	α Ph.−α Sat.	δ Ph.−δ Sat.		α Ph.−α Sat.	δ Ph.−δ Sat.
	m s	′ ″		m s	′ ″
Feb. 2	+ 1 55.4	+4 41	Feb. 18	+2 8.9	+5 44
6	1 59.2	4 58	22	2 11.6	5 57
10	2 2.7	5 14	26	2 14.0	6 8
14	+2 5.9	+5 27			

Titan Variable.—Titan, the brightest satellite of Saturn, has been found to be variable, from a discussion of observations taken on 60 nights by the late Oliver C. Wendell. The measurements were made with the 15-inch Equatorial as described in H.A. 69, Part 1. The light varies regularly from 8.53 to 8.77, when reduced to mean opposition. The average deviation of twelve groups from a smooth curve is ±0.023. The period, as in the case of the eighth satellite, Japetus, is the same as that of revolution. Accordingly, it is probably due, in both cases, to one side of the satellite being darker than the other. Titan is fainter than its mean brightness for only about one third of the time. The minimum occurs near the times of superior conjunction.

From similar observations, on 96 nights, Japetus was found to vary from 10.40 to 12.18. The maximum brightness occurs very near the western elongation.

EDWARD C. PICKERING.

Harvard College Observatory Bulletin 538.
Cambridge, Mass. Nov. 26, 1913.

VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on Dec. 1, 1913.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900	Decl. 1900	Magn
	h m	° ′			h m	° ′	
X Androm.	0 10.8	+46 27	13.5	Y Draconis	9 31.1	+78 18	12.0*d*
T Androm.	17.2	+26 26	<12.0	R Urs. Maj.	10 37.6	+69 18	12.4*d*
T Cassiop.	17.8	+55 14	7.5	T Urs.Maj.	12 31.8	+60 2	11.2*d*
R Androm.	18.8	+38 1	11.0 *i*	RS Urs. Maj.	34.4	+59 2	10.2
S Ceti	19.0	— 9 53	<11.0	S Urs. Maj.	39.6	+61 38	10.6*d*
Y Cephei	31.3	+79 48	<13.0	RR Urs. Maj.	13 22.5	+62 55	9.9
U Cassiop	40.8	+47 43	11.5	T Urs. Min.	32.6	+73 56	10.4 *i*
RW Androm.	41.9	+32 8	<13.0	U Urs. Min.	14 15.1	+67 15	9.8 *i*
V Androm	44.6	+35 6	9.2	RS Virginis	22.3	+ 5 8	10.8
RR Androm.	45.9	+33 50	10.6	S Urs. Min.	15 33.4	+78 58	8.2
RV Cassiop.	47.1	+46 53	8.2	V Cor. Bor.	46.0	+39 52	8.2
W Cassiop.	49.0	+58 1	11.0	X Herculis	59.6	+47 31	6.3
U Androm.	1 9.8	+40 11	13.1	RU Herculis	16 6.0	+25 20	7.3
– Androm.	10.4	+41 13	11.8	W Cor. Bor.	11.8	+38 3	9.6 *i*
S Piscium	12.4	+ 8 24	11.4*d*	U Herculis	21.4	+19 7	11.6 *i*
S Cassiop.	12.3	+72 5	10.6*d*	W Herculis	31.7	+37 32	9.2 *i*
R Sculptoris	22.4	—33 4	6.6	R Draconis	32.4	+66 58	12.2
RZ Persei	23.6	+50 20	12.8*d*	S Herculis	47.4	+15 7	8.8*d*
R Piscium	25.5	+ 2 22	9.9 *i*	RV Herculis	56.8	+31 22	10.6 *i*
RU Androm.	32.8	+38 10	9.8	RT Herculis	17 6.8	+27 11	10.8
Y Androm.	33.7	+38 50	9.7 *i*	V Draconis	56.3	+54 53	<14.0
X Cassiop.	49.8	+58 46	9.9	T Herculis	18 5.3	+31 0	8.8*d*
U Persei	53.0	+54 20	11.4	W Draconis	5.4	+65 56	11.0 *i*
S Arietis	59.3	+12 3	10.6	X Draconis	6.8	+66 8	<13.0 *i*
R Arietis	2 10.4	+24 35	11.0*d*	W Lyrae	11.5	+36 38	9.6 *i*
W Androm.	11.2	+43 50	9.4 *i*	SV Draconis	31.2	+49 18	13.6
T Persei	12.2	+58 30	9.2	X Ophiuchi	33.6	+ 8 44	6.8
Z Cephei	12.8	+81 13	11.6*d*	RY Lyrae	41.2	+34 34	13.4 *i*
o Ceti	14.3	— 3 26	8.9	R Scuti	42.2	— 5 49	7.4
S Persei	15.7	+58 8	10.0	RW Lyrae	42.1	+43 32	<13.0
RR Persei	21.7	+50 49	13.2	Z Lyrae	56.0	+34 49	11.0 *i*
U Ceti	28.9	—13 35	7.3	R Aquilae	19 1.6	+ 8 5	7.5
RR Cephei	29.4	+80 42	11.2 *i*	TT Aquilae	3.2	+ 1 9	7.0
R Trianguli	31.0	+33 50	8.2 *i*	V Lyrae	5.2	+29 30	<13.0
W Persei	43.2	+56 34	9.4	S Lyrae	9.1	+25 50	9.4
X Ceti	3 14.3	— 1 26	9.5 *i*	U Draconis	9.9	+67 7	13.6
Y Persei	20.9	+43 50	10.2*d*	W Aquilae	10.0	— 7 13	10.4*d*
U Camelop.	33.2	+62 19	7.4	R Sagittarii	10.8	—19 29	<10.0
W Tauri	4 22.2	+15 49	8.8	RY Sagittarii	10.0	—33 42	10.8
– Tauri	32.8	+ 8 9	12.6	TZ Cygni	13.4	+50 0	10.6
R Leporis	55.0	—14 57	7.6	U Lyrae	16.6	+37 42	9.8
V Orionis	5 0.8	+ 3 58	9.8	TT Cygni	37.1	+32 23	7.8
R Aurigae	9.2	+53 28	8.6	RT Cygni	40.8	+48 32	10.5*d*
W Aurigae	20.1	+36 49	<12.0	χ Cygni	46.7	+32 40	4.6
SU Tauri	43.2	+19 2	14.0	Z Cygni	58.6	+49 46	8.8
Z Tauri	46.7	+15 46	13.4	SV Cygni	20 6.5	+47 35	9.0
V Camelop.	49.4	+74 30	<13.0	S Aquilae	7.0	+15 19	9.4
Z Aurigae	53.6	+53 18	10.8	RW Aquilae	7.3	+15 46	9.3
W Camelop.	6 12.2	+75 30	10.0	R Sagittae	9.5	+16 25	9.5
V Monoc.	17.7	— 2 9	11.0 *i*	RS Cygni	9.8	+38 28	7.4
U Lyncis	31.8	+59 57	14.0	R Delphini	10.1	+ 8 47	8.4
S Lyncis	35.9	+58 0	14.0	RT Capricorni	11.3	—21 38	7.3
X Gemin.	40.7	+30 23	12.6*d*	V Sagittae	15.8	+20 47	11.5 *i*
Y Monoc.	51.3	+11 22	11.3 *i*	U Cygni	16.5	+47 35	8.8
V Can. Min.	7 1.5	+ 9 2	9.8*d*	RW Cygni	25.2	+39 39	8.0
U Can.Min.	35.9	+ 8 37	8.3	SZ Cygni	29.6	+46 16	9.3

Approximate Magnitudes of Variable Stars of Long Period on Dec. 1, 1913.—Continued.

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900. h m	Decl. 1900. ° ′	Magn
ST Cygni	20 29.9	+54 38	10.4 *i*	Y Pegasi	22 6.8	+13 52	10.7
Y Delphini	36.9	+11 31	13.5	RS Pegasi	7.4	+14 4	11.0*d*
S Delphini	38.5	+16 44	9.8	RV Pegasi	21.0	+29 58	<12.0
V Cygni	38.1	+47 47	9.6	S Lacertae	24.6	+39 48	9.6*d*
Y Aquarii	39.2	— 5 12	<13.0	S Aquarii	51.8	—20 53	12.4
T Delphini	40.7	+16 2	9.4	RW Pegasi	59.2	+14 46	13.2
V Delphini	43.2	+18 58	13.0	R Pegasi	23 1.6	+10 0	8.0
T Aquarii	44.7	— 5 31	11.2	V Cassiop.	7.4	+59 8	8.2 *i*
RS Capric.	21 1.7	—16 49	8.4	S Pegasi	15.5	+ 8 22	10.4*d*
TW Cygni	1.8	+29 0	12.0*d*	ST Androm.	33.8	+35 13	9.0
X Cephei	3.6	+82 40	<13.0	R Aquarii	38.6	—15 50	9.0
R Equulei	8.4	+12 23	13.2	Z Cassiop.	39.7	+56 2	9.2
T Cephei	8.2	+68 5	6.5*d*	V Cephei	51.7	+82 38	6.8
RR Aquarii	9.8	— 3 19	13.9	V Ceti	52.8	— 9 31	10.0*d*
W Cygni	32.2	+44 56	5.8	R Cassiop.	53.3	+50 50	10.0*d*
S Cephei	36.5	+78 10	9.6*d*	Y Cassiop.	58.2	+55 7	12.1
RV Cygni	39.1	+37 34	7.5	SV Androm.	59.2	+39 33	9.5 *i*
T Pegasi	22 4.0	+12 3	<13.0				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign < that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—H. C. Bancroft, Jr., T. C. H. Bouton, N. Bruseth, A. B. Burbeck, A. P. C. Craig, C. E. Furness, E. Gray, S. C. Hunter, S. H. Huntington, M. W. Jacobs, Jr., J. B. Lacchini, F. C. Leonard, O. Mach, C. Y. McAteer, W. T. Olcott, P. G. O'Reilly, E. Padova, E. W. Putnam, H. M. Swartz, D. Todd, H. W. Vrooman and I. E. Woods.

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and May E. Abbott at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of maxima in 1914 February d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7		15 3		
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	2 9;	10 12;	18 16;	26 19
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	7 11;	15 4;	22 22	
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2		6 12;	21 7	
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	6 17;	14 15;	22 14	
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	3 22;	11 17;	19 12;	27 7
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	2 12;	9 18;	17 1;	24 8
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		13		
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	6 18;	15 8;	23 22	
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	3 17;	14 20;	25 23	
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	1 3;	12 18;	24 9	
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	2 3;	9 19;	17 11;	25 3
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3		11 1;	21 4	
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	3 5;	10 22;	18 16;	26 9
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	1 1;	6 14;	12 2;	23 4
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	2 7;	9 20;	17 10;	24 23
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		4 9		
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	2 17;	9 21;	17 2;	24 7

Maxima of Variable Stars of Short Period.—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1914. February							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h
W Gemin.	6 29.2	+15 24	6.7— 7.5	7 22.0	5 3;	13 1;	20 23;	28 21				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7		11 1;	21 5					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		17 1						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	4 10;	12 8;	20 7;	28 6				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	4 15;	11 8;	18 0;	24 17				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	8 7;	17 14;	26 20					
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	6 13;	15 7;	24 3					
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 0.0		21						
RR Leonis	10 02.1	+24 29	9.1 - 10.1	0 10.9	1 1;	7 19;	21 10;	28 5				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	2 0;	8 15;	21 20;	28 10				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8		2 17;	12 9;	22 0				
SW Draconis	12.8	+70 04	8.8 — 9.6	0 13.7	4 4;	12 4;	20 3;	28 3				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	7 17;	14 11;	21 4;	27 22				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	6 18;	12 13;	18 9;	24 5				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	3 1;	7 18;	17 3;	26 12				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5		5 8;	22 15					
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	2 19;	11 0;	19 5;	27 10				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	7 7;	14 8;	21 8					
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	7 4;	15 9;	23 14					
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	3 20;	9 8;	20 8;	25 20				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	3 17;	11 6;	18 19;	26 8				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	7 3;	14 13;	21 23					
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	2 16;	9 11;	16 6;	23 0				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	6 10;	12 18;	19 1;	25 9				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	5 0;	14 18;	24 13					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	7 5;	16 2;	24 22					
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	2 19;	8 20;	20 23;	27 1				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	5 15;	9 15;	16 15;	23 15				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		1 3;	18 6					
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	1 3;	8 18;	16 8;	23 22				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	4 21;	10 15;	22 4;	27 23				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	5 0;	11 18;	18 12;	25 6				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	2 8;	12 17;	23 1					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	5 21;	11 22;	17 22;	23 23				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	4 3;	10 6;	22 13;	28 16				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	3 15;	9 14;	21 11;	27 10				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	2 3;	11 5;	20 8					
U Aquilae.	19 24.0	− 7 15	6.2— 6.9	7 00.6	1 7;	8 8;	15 9;	22 9				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	4 11;	11 11;	18 11;	25 11				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	5 8;	13 8;	21 7					
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	7 5;	14 22;	22 14					
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	2 11;	9 15;	16 19;	23 23				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	2 15;	11 0;	19 9;	27 18				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	4 15;	10 22;	17 6;	23 14				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3		5 10;	21 19					
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	2 2;	10 23;	19 20;	28 17				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	2 6;	9 0;	15 17;	22 11				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	3 6;	9 23;	16 16;	23 9				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		15 14						
VY Cygni	21 00.4	+39 34	8.8 — 9.5	7 20.6	2 23;	10 20;	18 16;	26 13				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	4 15;	11 12;	18 10;	25 7				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	5 17;	10 14;	20 7;	25 4				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	3 18;	12 10;	21 1					
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	6 0;	11 9;	22 3;	27 12				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1		8 17;	19 14					
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	2 21;	9 7;	22 3;	28 13				
V Lacertae	22 44.5	+55 48	8.2— 8.9	4 23.6	5 14;	10 14;	20 13;	25 13				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	6 4;	11 14;	22 12;	27 22				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	2 3;	8 10;	21 0;	27 7				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	7 17;	19 20						
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	4 12;	9 11;	19 11;	24 11				

Minima of Variable Stars of Short Period.

[Calculated by May E. Abbott, at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1914 February							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			6 4					
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	2 20;	10 13;	18 5;	25 21				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	5 1;	12 11;	19 22;	27 8				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	3 18;	11 6;	18 17;	26 5				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	2 12;	9 14;	20 20;	26 22				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	5 7;	12 11;	19 14;	26 18				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	1 23;	8 20;	15 17;	22 13				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	5 1;	12 5;	19 9;	26 13				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3 19;	12 14;	21 9					
ST Persei	2 53.7	+38 47	8.5—10.5	2 15.6	7 23;	15 22;	23 20					
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	1 13;	7 7;	18 18;	24 12				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	2 4;	8 23;	15 18;	22 13				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	6 16;	14 13;	22 11					
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	2 16;	11 0;	19 7;	27 14				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	4 21;	12 18;	20 16;	28 13				
RW Persei	13.3	+42 04	8.8—11.0	13 04.8		12 12;	25 16					
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	8 9;	17 20;	27 6					
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1		6 23;	19 9					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	1 10;	8 2;	21 10;	28 2				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	3 20;	9 7;	20 5;	25 16				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	1 21;	7 22;	19 23;	25 23				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	1 12;	10 4;	18 20;	27 12				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	5 15;	16 0;	26 10					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	5 2;	13 3;	21 3					
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	4 3;	9 20;	21 7;	27 1				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	6 5;	11 19;	23 0;	28 14				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	4 13;	12 18;	20 23					
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	2 4;	9 19;	17 10;	25 1				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	3 12;	15 17;	27 22					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	3 16;	10 20;	18 0;	25 4				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	1 10;	10 12;	19 14;	28 16				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	9 1;	18 8;	27 15					
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	9 21;	19 19						
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	3 15;	12 0;	20 10;	28 20				
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	1 23;	8 10;	21 6;	27 17				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	6 1;	13 8;	20 14;	27 21				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	5 1;	13 4;	21 7					
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	4 23;	14 11;	23 23					
RX Hydrae	9 0.8	− 7 52	9.1—10.5	2 6.8	6 21;	16 0;	25 3					
S Antliae	27.9	−28 11	6.3— 6.8	0 07.8	4 9;	10 20;	17 8;	23 20				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	1 14;	7 12;	19 9;	25 7				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	6 16;	15 2;	23 12					
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	3 8;	12 14;	21 21					
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	3 21;	10 11;	17 2;	23 16				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	1 0;	9 19;	18 14;	27 10				
RW Urs. Maj.	35.4	−52 34	10.3—11.4	7 07.9	3 6;	10 14;	17 22;	25 6				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	2 20;	9 15;	16 10;	23 5				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	7 9;	14 22;	22 10					
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	6 12;	13 22;	21 9;	28 19				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	7 5;	14 5;	21 4;	28 4				
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	1 16;	8 14;	15 11;	22 9				
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	5 1a;	13 20;	22 6					
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	3 10;	11 1;	18 17;	26 9				
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	3 0;	10 8;	17 16;	25 0				

Minima of Variable Stars of Short Period.—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean time of minima in 1914 February
	h m	° ′		d h	d h d h d h d h
SX Ophiuchi	16 12.6	— 6 25	10.5—11.2	2 01.5	5 16; 13 22; 22 4
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	3 6; 12 3; 20 23
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	2 9; 13 11; 23 3
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	5 1; 11 20; 18 15; 25 11
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	3 0; 11 9; 19 19; 28 4
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	6 20; 12 23; 19 3; 25 7
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	7 9; 14 14; 21 19; 29 0
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	2 14; 9 23; 17 8; 24 17
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	8 7; 16 12; 24 16
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	3 23; 11 12; 19 1; 26 14
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	8 7; 16 1; 23 19
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	1 12; 9 12; 17 12; 25 11
WX Sagittae	53.6	—17 24	9.2—10.8	2 03.1	5 2; 13 14; 22 3
WY Sagittae	17 54.9	—23 1	9.5—10.6	4 16.0	8 7; 17 15; 26 23
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	8 3; 18 11; 28 19
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	4 13; 11 19; 19 1; 26 7
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	5 17; 12 15; 19 13; 26 11
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	5 1; 20 4
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	5 20; 14 2; 22 9
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	5 1; 13 23; 22 20
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	2 13; 10 20; 19 3; 27 11
RR Draconis	40.8	+62 34	9.3—13	2 19.9	5 4; 13 16; 22 4
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	3 15; 10 7; 16 22; 23 14
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	8 19; 21 17
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	4 16; 14 5; 23 18
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	5 21; 13 11; 21 1; 28 15
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	7 8; 14 13; 21 18; 28 23
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	3 14; 12 13; 21 12
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	5 14; 12 8; 19 2; 25 21
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	1 19; 9 3; 16 12; 23 21
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	4 8; 9 13; 20 1; 25 7
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	5 14; 12 2; 18 15; 25 3
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	6 14; 12 14; 18 14; 24 15
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	2 7; 8 23; 22 5; 28 20
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	9 23; 19 2; 28 6
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	3 13; 12 0; 20 10; 28 20
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	2 2; 8 20; 15 15; 22 10
UW Cygni	19.6	+42 55	10.5—13	3 10.8	5 19; 12 17; 19 14; 26 12
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	26 10
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	9 9; 18 23; 28 14
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	6 7; 15 12; 24 17
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	3 15; 11 3; 18 15; 26 2
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	3 12; 9 8; 21 1; 26 21
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	2 2; 12 4; 22 7
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	1 14; 9 0; 16 9; 23 18
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	8 10; 18 2; 27 19
RY Aquarii	14.8	—11 14	8.8—10.4	1 23.2	1 7; 9 4; 17 1; 24 22
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	24 22
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	1 2; 11 6; 21 9
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	2 4; 7 9; 17 18; 28 3
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.6	2 16; 8 2; 19 0; 24 10
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	4 16; 12 23; 21 6
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	2 19; 10 8; 17 21; 25 9
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	6 22; 15 3; 23 9

COMET AND ASTEROID NOTES.

New Comet 1913 *f* (Delavan.)—A cablegram from Professor Hussey, director of the Observatory at LaPlata, Argentina, announces the discovery of a comet by Delavan on December 17. The comet was picked up at Goodsell Observatory on December 20, the first clear night after receipt of the announcement. It is a small comet, easily seen but not conspicuous with our 5-inch finder. It has a strong nuclear condensation, so that its position is easy to determine micrometrically. A very short extension, of the coma toward the northeast indicates at least the beginning of formation of a tail.

The comet is in the northwestern corner of the constellation Eridanus and is moving very slowly toward the northwest.

The following are all the observed positions which have come to hand as we go to press.

Greenwich Mean Time	R. A. h m s	Decl. ° ′ ″	Observer	Place
Dec. 17.6018	3 03 19.2	—7 25 24	Hussey	LaPlata
20.5968	3 00 40.1	—7 08 11	Wilson	Northfield
22.5622	2 59 00.7	—6 56 00	Wilson	Northfield

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Nov.-Dec., 1913.—An unusually cloudy month is reflected in a slight decrease in the number of observations, but in spite of this fact we have broken our record for the number of variables observed, 134. This is good evidence that the effort to extend the work in accordance with Professor Pickering's suggestion is already bearing fruit.

Nothing is more gratifying and encouraging than the signs of awakened interest in this branch of telescopy, as evidenced by the steady increase in our membership, and it is certainly flattering to all concerned that after two years' work so many should apply for membership in our organization. We welcome to our ranks this month the following observers. The report abbreviation, and the aperture of the refractors used by the observers follow the names in each case:

Howard O. Eaton, Madison, Wis. "E" 6 inch.
Edmund Mills, New York City, "Mi" 3¼ inch.
Delos H. Bacon, Florence, Ala. "Bn" 3¼ inch.
W. D. Wilkes, Indianapolis, Ind. "Wk" 3 inch.
Lemont Barbour, New York City, "Bb" 3 inch.
Charles F. Richter, Los Angeles, Cal. "R" 3 inch.

We have, therefore, quite a class of beginners who can be safely trusted to cover many of the better known and regular variables, leaving the more experienced observers free to add the neglected variables to their list.

We expect soon to have a large number of blue prints available for distribution so that every member will have complete sets of the better-known variables. To these will shortly be added a number of charts of the neglected variables, and thus it is hoped that the coming year will see a wide extension of the work and a more efficient service rendered.

Mr. H. C. Bancroft, Jr., with 184 observations again leads the class, and deserves special mention for several beautifully executed light curves. These were blue printed and are models of excellence.

Dr. Gray, with observations of seventy variables this month, has credit for the largest number of variables observed by any member in one month.

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1913.

001032
S Sculptoris

Mo.	Day	Est	Obs.
11	21	10.0	G
	25	8.5	Ba
12	2	7.9	G

001755
T Cassiop.

Mo.	Day	Est	Obs.
11	3	7.8	Bu
	4	7.9	M
	5	7.7	Ba
	22	7.9	Ba
	26	7.6	Bu
	30	7.7	G
12	3	8.4	S

001838
R Androm.

Mo.	Day	Est	Obs.
11	20	10.9	Hu
	22	11.0	M

003179
Y Cephei

Mo.	Day	Est	Obs.
11	4	12.7	Ba
	22	12.8	Ba

004435
V Androm.

Mo.	Day	Est	Obs.
11	3	9.4	Bu
	4	9.2	Ba
	17	9.4	O
	21	9.5	Ba
	22	9.2	Hu
	25	9.7	O
	26	9.2	Bu

004533
RR Androm.

Mo.	Day	Est	Obs.
11	4	11.5	Ba
	17	10.8	O
	21	10.7	Ba
	22	10.8	Hu
	25	10.7	O

004746
RV Cassiop.

Mo.	Day	Est	Obs.
10	31	10.2	L
11	8	9.0	L
	14	9.0	Fu
	17	8.7	L
	18	8.6	L
	21	8.6	Fu

004958
W Cassiop.

Mo.	Day	Est	Obs.
11	5	11.9	Ba
	17	11.9	J
	25	11.2	Ba

010940
U Androm.

Mo.	Day	Est	Obs.
11	4	13.2	Ba
	25	13.2	Ba

011208
S Piscium

Mo.	Day	Est	Obs.
11	17	12.2	O
	25	11.1	O
	25	11.5	Ba

011272
S Cassiop.

Mo.	Day	Est	Obs.
11	5	9.8	Ba
	20	10.0	M
	25	10.5	Ba

012233 a
R Sculptoris

Mo.	Day	Est	Obs.
11	21	6.8	G
12	2	7.0	G

012502
R Piscium

Mo.	Day	Est	Obs.
11	3	13.0	O
	17	11.5	Fu
	24	10.1	S

013238
RU Androm.

Mo.	Day	Est	Obs.
11	17	9.9	J

013338
Y Androm.

Mo.	Day	Est	Obs.
11	4	12.8	Ba
	17	10.8	J
	15	10.1	Ba

014958
X Cassiop.

Mo.	Day	Est	Obs.
11	14	10.2	Fu
	21	9.9	Fu

015254
U Persei

Mo.	Day	Est	Obs.
11	5	11.2	Ba
	22	11.3	Ba
	26	11.3	Bu

015611
S Arietis

Mo.	Day	Est	Obs.
11	3	10.6	Fu
	17	10.6	Fu

021024
R Arietis

Mo.	Day	Est	Obs.
11	3	10.5	Bu
	4	11.2	Br
	5	11.3	Br
	6	11.5	Br
	26	11.0	Bu

021258
T Persei

Mo.	Day	Est	Obs.
11	3	9.4	Bu
	26	9.2	Bu

021403
o Ceti

Mo.	Day	Est	Obs.
10	30	9.1	L
11	3	8.8	Bu
	4	9.0	Ma
	4	8.7	G
	5	9.0	Br
	15	9.0	G
12	16	9.5	C
	17	9.4	C
	18	9.0	L
	20	8.8	G
	20	9.0	O
11	21	9.3	C
	21	8.8	Le
	21	9.0	Hu
	22	9.0	C
	23	8.8	C
	24	9.0	Ma
	25	9.0	O
	25	8.7	Ba
	25	8.8	C
	26	8.6	Bu
	27	8.7	G
	3	8.8	O

021558
S Persei

Mo.	Day	Est	Obs.
	3	9.4	Bu
	5	8.9	Ba
	16	9.7	C
	17	9.7	C
12	21	9.7	C
	22	10.0	Ba
	22	9.8	C
	23	9.8	C
11	24	9.8	S
	25	9.9	C
	26	10.0	Bu
12	1	9.4	G

022150
RR Persei

Mo.	Day	Est	Obs.
11	5	11.8	Fu

022813
U Ceti

Mo.	Day	Est	Obs.
	3	7.2	Bu
	17	7.6	C
	20	6.9	G
12	21	7.6	C
	22	7.6	C
	23	7.6	C
	25	7.4	C
	26	7.4	Bu
11	30	7.3	Ba
12	2	7.1	G

023133
R Trianguli

Mo.	Day	Est	Obs.
11	4	9.2	G
	5	9.0	Ba
12	17	8.9	O

R Trianguli

Mo.	Day	Est	Obs.
11	21	8.6	Le
	21	8.3	G
	26	8.5	O
	27	8.1	G
	30	8.2	Ba
12	2	8.1	G
	3	8.0	O

024356
W Persei

Mo.	Day	Est	Obs.
	3	9.0	Bu
	4	9.8	
	4	9.8	Ma
	4	10.1	Br
12	5	9.5	Ba
	5	10.1	Br
	6	10.4	Br
	11	9.8	Br
	17	9.2	M
	17	9.9	Br
	19	9.7	Br
	20	9.7	V
	21	9.9	Le
	21	9.2	Hu
	22	9.1	M
	22	10.0	Ba
12	24	9.4	G
	25	10.0	O
	26	8.7	Bu
	4	9.7	V

032043
Y Persei

Mo.	Day	Est	Obs.
11	1	9.7	Ma
	2	9.4	Ba
	3	9.6	Bu
	4	9.8	Ma
	5	9.2	Ba
	7	8.7	G
	17	9.9	M
	21	8.9	Hu
	22	10.0	M
	24	9.9	Ma
	25	10.1	O
	25	9.7	Ba
	26	9.8	Bu
12	1	9.9	G
	3	10.1	O

033362
U Camelop.

Mo.	Day	Est	Obs.
11	4	8.0	Br
	4	7.3	Ba
	5	8.0	Br
	6	8.0	Br
	17	7.8	Br
	19	7.7	Br
	21	7.1	Le
12	3	7.5	O

042215
W Tauri

Mo.	Day	Est	Obs.
11	2	10.6	Ba
	3	10.6	Bu
	5	10.5	Ba
	12	10.0	Ba
	20	10.0	O
	20	9.5	G
	21	9.3	G
	22	10.0	C
	22	10.4	M
	25	9.9	O
	25	10.0	C
	26	10.0	Bu
	27	8.8	G
12	1	8.5	G
	3	9.7	O

043274
X Camelop.

Mo.	Day	Est	Obs.
11	2	9.2	Ba
	4	9.0	Ba
	12	9.0	Ba
	17	8.9	O
	20	8.8	O
	21	8.8	Ba
	22	8.9	G
	25	8.8	O
12	3	8.7	O

045514
R Leporis

Mo.	Day	Est	Obs.
11	6	8.1	G
	8	9.0	L
	21	8.6	G
	21	8.2	Le
	26	7.6	Bu
12	1	8.4	G

050953
R Aurigae

Mo.	Day	Est	Obs.
11	7	9.0	B
	26	8.6	Bu
12	3	9.2	O
	4	9.1	B

052404
S Orionis

Mo.	Day	Est	Obs.
11	22	10.2	G
12	2	10.0	G

054920
U Orionis

Mo.	Day	Est	Obs.
11	21	11.0	Hu
	26	10.2	Bu

060450
X Aurigae

Mo.	Day	Est	Obs.
11	2	10.0	Ba
	5	10.6	Ba

060547
SS Aurigæ

Mo.	Day	Est	Obs.
11	2	12.0	Ba

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1913.—Continued.

060675
W Camelop

Mo.	Day	Est.	Obs.
11	6	9.7	Fu
	11	10.0	Fu

064932
NOVA GEMIN.

10	30	10.6	L
11	22	10.8	M
	26	10.0	Bu
12	2	11.0	G

065208
X Monoc.

11	8	7.7	L

070122
R Gemin.

11	26	8.2	Hu

070310
R Can. Min.

11	8	8.7	L

072708
S Can. Min.

11	8	10.6	L

073508
U Can. Min.

11	8	8.8	L
	21	8.3	Ba

074922
U Gemin.

11	26	9.4	Hu

081112
R Cancri

11	8	10.3	L

081633
T Lyncis

12	1	10.7	G

082405
RT Hydrae

11	8	8.9	L

085120
T Cancri

11	8	9.6	L

094211
R Leonis

11	8	10.0	L

103012
U Hydrae

11	8	4.7	L

103769
R Urs. Maj.

10	30	11.5	L
11	2	11.7	Ba
	5	11.8	Ba
	21	12.2	Ba
	26	12.3	B
12	5	12.4	B

123160
T Urs. Maj.

Mo.	Day	Est.	Obs.
11	3	10.1	Ba
	4	10.1	Br
	5	10.1	Br
	6	10.3	Ba
	18	10.5	L
	21	11.1	Ba

123459
RS Urs. Maj.

11	5	9.4	Fu
	25	9.9	Fu

123961
S Urs. Maj.

11	3	10.1	Ba
	4	10.3	Br
	5	10.4	Br
	6	10.2	Ba
	18	10.4	L
	21	10.8	Ba

133273
T Urs. Min.

11	5	12.2	Fu
	21	11.3	Fu
12	1	10.0	G

132063
RR Urs. Maj.

11	5	11.6	Fu
	25	9.6	Fu

133273
T Urs. Min.

11	3	12.1	Ba
	21	10.3	Ba

133674
V Urs. Min.

11	21	7.6	G
	23	7.7	G
12	1	7.8	G

141567
U Urs. Min.

11	2	11.2	Ba
	5	11.1	Ba
	22	10.8	Ba
12	3	9.7	S

142539
V Boötis

10	31	8.5	L
11	4	8.3	Br
	4	8.0	Ba
	6	8.4	Br

142584
R Camelop.

11	26	12.4	B

153378
S Urs. Min.

Mo.	Day	Est.	Obs.
10	31	8.6	L
11	2	9.0	Ba
	3	8.4	Bu
	3	8.8	B
	5	9.0	Ba
	13	8.6	G
	16	8.7	G
	18	9.2	L
	22	9.5	Ba
	23	8.7	G
	26	8.2	Bu
12	1	9.3	G

154428
R Cor. Bor.

10	31	6.0	L
11	1	6.1	Ma
	3	6.0	Ba
	4	6.1	Br
	5	6.0	Ba
	5	6.1	Br
	5	6.0	Ba
	6	6.0	Br
	6	6.0	Ba
	8	6.0	L
	10	6.0	Ba
	16	5.7	C
	18	6.0	L
	19	6.2	Br
	21	6.0	Ba
	21	6.0	G
	22	6.0	Ba
	23	6.1	Le

154539
V Cor. Bor.

11	4	9.0	Ba
	16	8.5	G
	21	8.4	G

155947
X Herculis

10	31	6.3	L
	11	18	6.3	L

160625
RU Herculis

11	2	8.5	G
	2	8.2	Ba
	4	8.0	Ba
	12	7.7	Ba
	22	7.3	Ba

163137
W Herculis

11	2	9.8	G
	4	9.0	M
	22	9.4	G
	23	9.7	Le

163172
R Urs. Min.

Mo.	Day	Est.	Obs.
11	2	9.5	Ba
	3	10.2	Bu
	7	9.4	Bu
	22	9.3	Ba
	26	10.5	Bu
12	1	9.2	G

163266
R Draconis

10	31	11.5	L
11	3	11.6	Ba
	3	11.5	Bu
	18	11.9	L
	21	12.0	Ba

164055
S Draconis

11	2	8.3	G

164715
S Herculis

11	2	8.2	G
	2	8.1	Ba
	4	8.2	Ba
	17	8.5	Ba
	22	8.6	Ba

165631
RV Herculis

11	2	12.6	Ba
	5	12.3	Ba
	6	11.8	Fu
	12	11.6	Ba
	17	11.4	Ba
	20	10.6	Fu
	22	10.9	Ba

170627
RT Herculis

11	2	11.5	Ba
	5	11.3	Ba
	20	10.9	Ba

171401
Z Ophiuchi

11	3	11.3	Ba

175458
T Draconis

11	2	11.1	Ba
	17	11.2	V
	22	11.0	Ba

180565
W Draconis

11	2	11.4	Ba
	17	10.4	Ba

180531
T Herculis

10	31	7.8	L
11	1	8.0	Ma
	2	7.5	G

T Herculis

Mo.	Day	Est.	Obs.
11	4	8.0	Ma
	4	7.8	M
	6	7.5	G
	8	7.8	St
	9	7.8	St
	10	7.4	G
	14	7.5	G
	15	8.0	L
	16	7.8	St
	16	8.1	C
	17	8.1	O
	17	8.1	C
	17	8.2	V
	18	8.3	L
	20	7.9	St
	20	8.5	O
	21	7.9	G
	21	8.7	Ma
	21	8.3	C
	21	8.2	St
	22	8.3	C
	23	8.4	St
	23	8.5	C
	24	8.6	V
	25	8.6	C
	30	8.6	St
12	1	9.0	G

181136
W Lyrae

11	1	10.6	Bu
	4	9.7	M
	6	9.5	M
	6	9.6	B
	17	8.9	M
	17	9.2	O
	20	8.8	M
	20	9.1	O
	22	9.4	G
	23	9.2	Le
	25	9.0	C
	26	9.0	B
12	1	9.1	G
	3	8.8	O

183308
X Ophiuchi

11	3	6.9	Ba
	5	6.9	Ba
	12	6.8	Ba
	17	6.7	Ba
	22	6.7	Ba
	22	6.8	G

184205
R Scuti

10	31	5.7	L
11	1	5.7	Ma
	2	6.1	Ba

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1913.—Continued.

R Scuti

Mo.	Day	Est.	Obs.
11	3	6.2	Ba
	4	5.8	Br
	4	6.2	Ba
	4	5.8	G
	5	5.8	Br
	5	6.2	Ba
	6	5.8	G
	6	6.3	Ba
	7	6.4	Ba
	12	6.9	Br
	12	6.7	Ba
	15	6.8	L
	16	7.0	C
	17	7.1	Ba
	17	7.0	C
	17	6.9	L
	18	6.9	L
	21	7.2	Ba
	21	7.0	C
	22	7.2	C
	22	6.4	G
	23	7.4	C
	25	7.3	C

190108
R Aquilae

Mo.	Day	Est.	Obs.
11	21	8.2	G
	27	7.8	G
	30	7.5	G

190707
W Aquilae

Mo.	Day	Est.	Obs.
11	6	10.1	Fu
	20	10.4	Fu

190926
X Lyrae

Mo.	Day	Est.	Obs.
11	2	9.0	Ba
	7	9.2	G
	22	9.4	Ba

191019
R Sagittarii

Mo.	Day	Est.	Obs.
10	31	9.6	L
11	1	9.6	Bu

191637
U Lyrae

Mo.	Day	Est.	Obs.
11	3	9.0	Ba
	5	9.3	Ba
	17	10.1	O
	22	9.3	Ba
	22	9.9	G

193449
R Cygni

Mo.	Day	Est.	Obs.
11	22	11.8	B
12	4	11.9	B

193732
TT Cygni

Mo.	Day	Est.	Obs.
10	31	7.8	L
11	1	7.7	Bu
	1	8.0	Ma
	3	7.5	Ba
	4	8.0	Ma
	16	8.0	G
	16	8.3	C
	17	8.3	C
	18	8.0	L
	21	7.6	Hu
	21	8.4	C
	22	8.3	C
	22	7.2	Ba
	22	7.8	B
	23	8.3	C
	24	8.3	Ma
	25	8.2	C
	26	7.9	B
	30	7.6	Hu
	30	7.8	G
12	4	7.6	B

194048
RT Cygni

Mo.	Day	Est.	Obs.
10	31	9.3	L
11	1	9.0	Bu
	1	8.9	Ma
	3	8.9	Ba
	4	9.0	Ma
	4	8.8	M
	4	8.8	G
	5	9.0	Ba
	7	9.0	G
	10	9.2	G
	13	9.3	G
	16	9.8	G
	16	9.0	C
	17	9.5	Ba
	17	10.0	O
	17	9.2	C
	17	9.3	M
	18	10.1	L
	20	10.2	G
	21	10.0	Hu
	21	9.8	Le
	21	9.8	C
	22	9.6	B
	22	9.8	Ba
	22	10.0	C
	23	10.1	C
	24	10.2	S
	25	10.3	O
	25	10.2	C
	27	10.5	G
	30	10.5	Hu
12	1	11.0	G
	4	10.7	B

194348
TU Cygni

Mo.	Day	Est.	Obs.
11	1	12.0	Bu
	4	10.5	G
	22	12.7	Ba

194632
χ Cygni

Mo.	Day	Est.	Obs.
10	30	4.9	L
	31	4.9	L
11	1	5.4	Ma
	1	5.0	Bu
	4	5.7	M
	4	5.4	Ma
	4	5.2	G
	5	5.3	Ma
	5	4.4	Le
	6	5.5	M
	6	5.2	G
	7	4.8	B
	7	5.2	G
	10	5.0	G
	14	5.2	G
	14	5.4	O
	15	4.8	L
	16	5.1	G
	16	5.2	C
	17	5.6	J
	17	5.4	O
	17	5.3	C
	17	5.2	M
	18	5.1	L
	20	5.2	G
	20	5.3	O
	21	4.5	Le
	21	5.6	C
	21	4.9	St
	21	5.9	Hu
	22	4.7	B
	22	5.6	C
	22	5.1	M
	23	5.7	C
	23	4.8	St
	24	5.1	Ma
	24	5.6	E
	25	5.3	O
	25	5.6	C
	26	4.6	B
	30	5.8	St
	30	5.6	O
	30	5.7	G
12	3	5.8	O
	4	5.4	B
	9	6.1	O

195849
Z Cygni

Mo.	Day	Est.	Obs.
11	14	8.5	G
	15	8.5	G
	20	8.6	G
	27	8.7	G
12	1	8.8	G

200647
SV Cygni

Mo.	Day	Est.	Obs.
11	1	9.0	Ma
	2	8.4	Bu
	3	8.1	Ba
	4	8.7	M
	5	8.7	Ma

SV Cygni

Mo.	Day	Est.	Obs.
11	6	8.6	G
	10	8.2	G
	16	9.0	C
	17	9.0	Ba
	17	9.1	C
	17	9.1	M
	20	8.6	Hu
	21	8.9	C
	21	8.6	Le
	22	8.9	Ba
	22	8.9	G
	22	9.0	C
	23	8.9	C
	25	8.9	C
	26	8.9	B
12	1	9.2	G
	4	8.7	B

200715 a
S Aquilae

Mo.	Day	Est.	Obs.
11	3	10.4	Ba
	15	9.2	G
	22	9.5	Ba
	22	9.4	M
	26	9.4	B
	30	9.4	G

200715 b
RW Aquilae

Mo.	Day	Est.	Obs.
11	1	9.4	Bu
	3	9.3	Ba
	22	9.1	M
	22	9.0	Ba
	26	9.4	B

200916
R Sagittae

Mo.	Day	Est.	Obs.
11	3	9.6	Ba
	15	8.8	G
	22	8.8	Ba
	26	9.0	B
	30	9.5	G

200938
RS Cygni

Mo.	Day	Est.	Obs.
11	1	7.4	Bu
	1	7.5	Ma
	3	6.8	Ba
	4	7.5	Ma
	7	7.2	G
	14	7.2	G
	16	7.3	C
	17	7.1	Ba
	17	7.3	C
	21	7.4	Le
	21	7.4	C
	22	7.2	Ba
	22	7.4	C
	23	7.4	C
	24	7.3	Ma
	25	7.5	O
	25	7.4	C

201008
R Delphini

Mo.	Day	Est.	Obs.
11	2	8.4	Bu
	6	7.9	Fu
	14	8.5	G
	14	8.1	Fu
	17	8.5	V
	17	8.5	O
	20	8.2	Fu
	20	8.5	O
	22	8.4	B
	23	8.6	G
	24	8.9	V
	25	8.3	O
	26	8.5	B
12	3	8.8	O

201121
RT Capricorni

Mo.	Day	Est.	Obs.
11	2	6.8	Ba
	17	7.6	L
	23	7.0	G

201647
U Cygni

Mo.	Day	Est.	Obs.
10	31	9.0	L
11	2	8.8	Bu
	6	8.4	G
	16	9.0	C
	17	8.1	O
	17	8.6	M
	18	9.2	L
	22	8.9	G
	24	9.2	S
12	1	9.5	G
	3	8.4	O

202539
RW Cygni

Mo.	Day	Est.	Obs.
11	2	8.0	Bu
	3	7.7	Ba
	4	8.2	G
	6	8.4	G
	7	8.1	G
	10	8.0	G
	11	8.0	G
	12	8.2	G
	13	8.3	G
	14	8.1	G
	16	8.3	G
	17	8.0	Ba
	17	8.4	M
	20	8.4	G
	21	8.1	G
	22	8.3	M
	22	7.5	Ba
	23	8.2	G
	27	8.0	G

202946
SZ Cygni

Mo.	Day	Est.	Obs.
11	2	9.2	Bu
	2	9.5	Ba
	3	9.4	Ba
	4	9.6	Ba

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SZ Cygni

Mo.	Day	Est.	Obs.
11	4	9.8	M
	5	9.8	Le
	5	9.8	Ba
	5	10.4	Br
	6	9.8	Ba
	7	9.4	Ba
	10	8.9	Le
	10	8.7	Ba
	12	8.9	Ba
	16	9.4	Le
	16	9.8	C
	17	9.5	Ba
	17	9.4	M
	17	10.0	C
	20	9.4	Hu
	21	9.4	C
	21	9.6	Le
	21	9.8	Ba
	22	9.3	M
	22	9.4	Ba
	23	9.5	Le
	23	9.2	C
	24	9.4	Le
	25	8.7	Ba
	25	8.8	C
	26	8.8	B
	30	9.0	Ba
	30	9.6	Hu
12	3	9.6	Le
	4	9.8	Le
	4	9.0	B

202954
ST Cygni

Mo.	Day	Est.	Obs.
11	3	11.1	Ba
	17	10.9	Ba

203847
V Cygni

Mo.	Day	Est.	Obs.
11	2	10.6	Bu
12	1	11.2	G

203816
S Delphini

Mo.	Day	Est.	Obs.
11	15	9.0	G
	30	9.8	G

204016
T Delphini

Mo.	Day	Est.	Obs.
11	14	9.5	Fu
	15	9.1	G
	20	9.5	Fu
	22	9.2	G
	30	9.4	G

204405
T Aquarii

Mo.	Day	Est.	Obs.
11	23	11.4	Le
	27	11.2	G

205923
R Vulpeculae

Mo.	Day	Est.	Obs.
10	31	10.9	L

205928
TW Cygni

Mo.	Day	Est.	Obs.
11	14	11.0	Fu
	20	11.8	Fu

210116
RS Capricorni

Mo.	Day	Est.	Obs.
11	2	8.6	Bu
	3	8.1	Ba
	16	8.4	C
	17	8.4	C
	21	8.5	C
	22	8.4	C
	23	8.4	C
	23	8.4	G
	25	8.4	C

210612
R Equulei

Mo.	Day	Est.	Obs.
11	14	12.2	Fu
	22	12.9	Fu
	24	13.2	Fu

210703
RR Aquarii

Mo.	Day	Est.	Obs.
11	14	11.7	Fu
	25	13.9	Fu

210868
T Cephei

Mo.	Day	Est.	Obs.
10	31	5.3	L
11	1	5.8	Bu
	1	5.1	Ma
	3	5.5	Ba
	4	5.9	Ma
	4	5.6	Br
	5	5.7	Br
	16	5.2	G
	16	6.4	C
	17	6.5	O
	17	6.4	C
	17	6.4	V
	17	6.2	L
	20	5.7	G
	21	6.3	C
	22	6.0	Ba
	22	6.4	C
	22	6.3	Hu
	23	6.4	C
	23	6.0	Le
	24	6.0	Ma
	24	6.8	V
	25	6.5	O
	25	6.7	C
	30	6.3	O
12	3	6.3	O
	4	6.8	V

212030
S Microscop.

Mo.	Day	Est.	Obs.
11	23	10.5	G

213244
W Cygni

Mo.	Day	Est.	Obs.
10	30	5.7	L
	31	5.6	L
11	2	5.5	Bu
	6	6.1	G
	10	6.5	G
	14	6.4	G
	15	5.2	L
	16	5.9	C
	17	5.9	C
	18	5.1	L
	21	5.1	Le
	21	5.9	C
	22	5.9	C
	23	5.8	C
	25	5.9	C
	27	5.7	G

213678
S Cephei

Mo.	Day	Est.	Obs.
11	3	8.5	Ba
	16	9.5	G
	19	9.5	V
	22	8.5	Hu
	22	8.7	Ba
	23	9.3	Le
	24	9.2	S
	27	9.6	G
12	4	9.5	V

213753
RU Cygni

Mo.	Day	Est.	Obs.
11	19	9.2	V
12	1	8.8	G
	4	8.6	V

213843
SS Cygni

Mo.	Day	Est.	Obs.
10	30	11.8	L
	31	11.8	L
11	1	11.0	Bu
	2	11.7	Ba
	2	11.0	Bu
	3	11.7	Ba
	3	11.0	Bu
	4	11.0	Bu
	4	11.9	M
	4	10.5	G
	5	10.4	Bu
	5	11.1	Br
	5	10.0	Le
	6	10.2	Br
	6	9.8	G
	6	9.6	Bu
	6	9.5	M
	7	9.4	Br
	7	9.3	G
	7	9.2	Bu
	8	8.9	G

SS Cygni

Mo.	Day	Est.	Obs.
11	8	9.0	Bu
	9	8.5	G
	10	8.3	Le
	10	8.8	Bu
	10	8.5	Ba
	10	8.4	G
	11	8.4	G
	11	8.1	Br
	12	8.6	G
	12	8.5	Ba
	13	8.7	G
	14	8.7	G
	14	9.2	J
	14	9.1	O
	15	9.0	G
	15	8.9	L
	16	9.5	Le
	16	9.8	G
	16	9.0	C
	17	9.8	V
	17	9.9	Ba
	17	9.7	M
	17	9.5	O
	17	9.2	C
	17	10.2	Br
	17	10.5	J
	17	9.8	L
	18	10.1	L
	19	11.1	V
	19	11.1	Br
	20	11.1	Hu
	20	11.1	O
	20	10.4	M
	21	11.4	Le
	21	11.6	Ba
	21	11.5	Hu
	21	11.9	J
	22	11.7	Ba
	22	11.3	Hu
	23	11.8	Le
	24	11.8	Le
	25	11.8	Ba
	26	11.9	Hu
	30	11.9	Hu
	30	12.0	Ba
12	5	11 9	B

213937
RV Cygni

Mo.	Day	Est.	Obs.
11	1	7.7	Ma
	3	7.4	Ba
	3	8.0	Bu
	4	7.2	Ma
	4	8.0	M
	10	7.5	G
	16	8.3	C
	17	7.6	M
	17	7.5	Ba
	17	8.1	C
	20	7.5	Hu
	21	6.9	Le

RV Cygni

Mo.	Day	Est.	Obs.
11	20	8.0	C
	22	8.1	C
	22	7.5	Ba
	23	8.0	C
	24	7.2	Ma
	25	7.9	C
	30	7.5	Hu
12	5	7.2	B

220613
Y Pegasi

Mo.	Day	Est.	Obs.
11	3	10.3	Fu
	14	10.0	Fu
	23	10.7	V
	25	10.7	Fu

220714
RS Pegasi

Mo.	Day	Est.	Obs.
11	3	10.8	Fu
	14	10.6	Fu
	23	10.9	V
	25	10.8	Fu

221722
RT Aquarii

Mo.	Day	Est.	Obs.
11	23	10.0	G

221938
T Gruis

Mo.	Day	Est.	Obs.
11	22	9.0	G

222439
S Lacertae

Mo.	Day	Est.	Obs.
11	3	9.0	Ba
	14	9.6	Fu
	21	9.5	Ba

225120
S Aquarii

Mo.	Day	Est.	Obs.
11	2	12.0	Ba
	17	12.2	Ba

225914
RW Pegasi

Mo.	Day	Est.	Obs.
11	3	11.9	Fu
	14	12.4	Fu
	25	13.1	Fu

230110
R Pegasi

Mo.	Day	Est.	Obs.
11	3	8.2	Bu
	4	8.3	Br
	5	8.3	Br
	6	8.1	Br
	6	8.2	G
	11	8.0	Br
	13	8.2	G
	17	7.8	M
	17	8.0	Br
	17	8.0	O
	19	8.0	Br
	20	8.3	G

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1913—Continued.

R Pegasi

Mo.	Day	Est.	Obs.
	20	8.0	O
	22	7.7	M
	25	8.0	O
	26	8.2	Hu
	30	8.1	O
12	3	8.2	O

230759

V Cassiopeiae

Mo.	Day	Est.	Obs.
11	3	9.5	Ba
	6	9.6	M
	19	8.7	V
	21	8.3	Ba
12	4	8.0	V

231425

W Pegasi

Mo.	Day	Est.	Obs.
11	22	11.2	G
	23	10.8	V

231508

S Pegasi

Mo.	Day	Est.	Obs.
11	3	8.9	Fu
	4	8.6	Ba
	6	9.0	G
	13	9.3	G
	14	9.1	Fu
	17	9.5	O
	20	9.8	G
	20	9.7	O
	21	9.5	Ba
	25	10.3	O
	25	10.1	Fu
	30	10.4	O

233335

ST Androm.

Mo.	Day	Est.	Obs.
11	2	9.0	Ba
	5	9.0	Ba
	5	9.0	Bu
	17	9.0	Ba
	20	9.1	Hu
	21	9.0	Ba
	24	9.0	S

233815

R Aquarii

Mo.	Day	Est.	Obs.
11	2	9.0	Ba
	3	9.5	Bu
	17	9.0	Ba
	27	9.0	G

234852

RR Cassiop.

Mo.	Day	Est.	Obs.
11	17	11.3	Fu

235009

V Ceti

Mo.	Day	Est.	Obs.
11	3	9.3	Fu
	14	9.7	Fu
	25	9.8	Fu
12	2	9.6	G

235182

V Cephei

Mo.	Day	Est.	Obs.
10	30	6.4	L
	31	6.8	L
	31	6.6	L
11	8	6.7	L
	16	6.9	C
	17	6.9	C

V Cephei

Mo.	Day	Est.	Obs.
	22	6.7	C
	23	6.8	C
	25	6.5	C

235350

R Cassiop

Mo.	Day	Est.	Obs.
11	8	9.9	L
	16	9.3	C
	17	9.6	C
	20	9.4	Hu
	21	9.6	C
	22	9.8	C
	23	9.9	C

235939

SV Androm.

Mo.	Day	Est.	Obs.
11	4	10.7	Bu
	21	9.5	Ba

No. of Observations 909; No. of Stars Observed 134; No. of Observers 17;

We note with pleasure the resumption this month of contributed observations by Dr. Caroline E. Furness, "Fu", director of the Vassar College Observatory, flattering evidence of her interest in our organization.

The Rev. Victor Stepka, "St.", of Clayton, Mo., who became a member of the Association in 1911, and has heretofore been unable to contribute observations, joins the active list this month.

Mr. M. W. Jacobs, Jr., of Harrisburg, Pa., one of our best and most experienced observers, writes that he will have to give up observing regularly for a time. We deeply regret the loss of Mr. Jacobs' valuable observations and hope for their continuance in the near future.

Attention is called to the concerted observation of 213843 SS Cygni, on the night of Nov. 17, as a fine example of co-operative observing. Unfortunately there is an unusually wide variance in the estimates, which is difficult to account for, except for the fact that in the early evening the variable was so close to the zenith as to be difficult of direct observation.

The drop of approximately a magnitude in the variable *184205* R Scuti between Nov. 4 and 17 is interesting to note.

Members are urged to observe on every occasion the two extremely irregular variables 060547 SS Aurigæ, and 074922 U Geminorum. The former has been somewhat neglected of late. For those without circles it is much easier to locate than the latter.

Dr. Hartwig publishes the following calculated dates of maxima:

Nov. 10 S Herculis,
13 V Camelopard,
14 V Andromedæ,
18 X Camelopard.

A comparison with the observations of these variables in the report is therefore of special interest.

An article of interest to all variable star observers appeared in the November issue of "Knowledge", an English publication, entitled "The Nomenclature of Variable Stars" by F. A. Bellamy.

In this report, which is the first to appear since a plan for extending the work was suggested by Professor Pickering, it is apparent that a start has been made

toward this end. Sixteen of the eighty-six stars on Professor Pickering's list of neglected variables have been observed during the past month and a total of sixty-six observations secured. Messrs. Bancroft and Gray, and Miss Furness are largely responsible for this good showing. It is hoped that this extension of our work will make rapid progress and members are urged to increase their list to include these neglected stars.

Mr. Burbeck and the Secretary recently had the pleasure of visiting the Harvard college Observatory, where through the kindness of the Director every courtesy was extended. Professor Pickering was good enough to express the wish that our members could meet with him some day in a body and discuss matters of interest, a wish that we all hope may be realized.

WILLIAM TYLER OLCOTT.
Corresponding Secretary.

Norwich, Conn., Dec. 10, 1913.

GENERAL NOTES.

Our readers willl be pleased to note that Professor Wm. H. Pickering, who is now at the Harvard College Observatory station at Mandeville, Jamaica, W. I., for the purpose of studying Mars at the present opposition, proposes to send a monthly report of his observations to POPULAR ASTRONOMY. Many will doubtless be interested in seeing how well they can verify, with their own instruments and less favorable atmospheric conditions, the features and changes which Professor Pickering notes.

Mr. H. Knox Shaw has been appointed superintendent of the Helwân Observatory in Egypt.

Dr. Sebastian Albrecht has been appointed astronomer at the Dudley Observatory, Albany, N. Y.

Professor Newall has been made Deputy Director of the Cambridge Observatory, owing to the continued illness of Professor Sir Robert Ball.

Mr. W. E. Hartley, of Trinity College, has been appointed to succeed Mr Hinks as chief assistant at the Cambridge Observatory.

Professor Louis V. King, of the McGill University, has been granted the sum of $250 by the Rumford committee of the American Academy, to defray the expenses of computation for his research on "The Scattering and Absorption of Solar Radiation in the Earth's Atmosphere."

Sir Robert Stawell Ball, Lowndean professor of astronomy at Cambridge University, and director of the observatory, died on November 25, at the age of seventy-three years. He was professor of astronomy in the University of Dublin and Astronomer Royal of Ireland from 1874 to 1892, when he was called to Cambridge. (*Science*, December 5, 1913.)

Leander McCormick Observatory.—Director S. A. Mitchell writes that he has ordered a double slide plate holder from Brashear and will take up work in the photographic determination of stellar parallax.

New Observatory at Alton, Hants, England.—The London Astronomical Society opened on November 7, at Alton, Hants, a new observatory erected by one of its members, Mr. James H. Worthington. The site selected is over 600 feet above sea level, near the Melstead station. Here Mr. Worthington has erected what, both in finish of instruments and in general facilities, is said to be the finest private observatory in England. It is more than 20 miles from any manufacturing town, and the atmosphere is not affected by any strong artificial lighting. There are altogether six telescopes. The two largest are under domes 24 feet and 22 feet in diameter respectively, and are a 20-inch reflector and a 10-inch refractor. (*Science* Nov. 28, 1913.)

Hind's Variable Nebula.—Mr. Borrelly, in *Comptes Rendus* August 18, announces that the nebula N.G.C. 6760 is now at maximum brightness, as it has been visible for some months in his comet-seeker of 16.5 cm aperture, in which it cannot usually be seen. M. Bigourdan, writing later, asks for confirmation of this fact and suggests the need for a series of dated observations, which could be made with small telescopes, to confirm the variability of the nebula.

New Photographic Telescope at Nantucket.—The new seven and one half inch photographic telescope was placed in position in the Memorial Observatory of the Nantucket Maria Mitchell Association on November 15, the mounting and final adjustment by Alvan Clark and Son's Corporation, completing the work. The lens was made by T. Cooke & Sons, York, England.

It has been subjected to various tests at Harvard College observatory by the Director, Dr. Edward C. Pickering, personally, and by his several assistants who have given it careful attention. Rev. Joel H. Metcalf, whose astronomical discoveries, by means of photographs, are well known, has also carefully examined its work. By all of these it is pronounced good.

The Nantucket Observatory is now well equipped for photographic study of Asteroids or other heavenly bodies.

Astronomical Fellowships of the Nantucket Maria Mitchell Association.—The following circular has been issued in regard to the fellowships of the Nantucket Maria Mitchell Association:

In accordance with the provision of circulars issued in October, 1911, and October 1912 (giving preference to the same candidate for three successive years, provided said candidate should have proved herself efficient and fitted for the position), the Fellowship of $1,000 for the year beginning June 15, 1914, has been awarded to Margaret Harwood, who not only has filled all requirements, but in addition has been in every way acceptable to the Association and to the residents of Nantucket.

The year beginning June 15, 1915, is the quadrennial year provided for by vote of the Board of Managers April 26, 1911; the appointee of three previous years of continuous efficiency is priviledged on the fourth to avail herself of the entire year for study and research in an observatory of her own selection.

In order that the Nantucket Observatory may be provided for from June 15, 1915, to December 15, 1915, the Nantucket Maria Mitchell Association offers a second Fellowship of Five Hundred Dollars for the quadrennial year under conditions similar to those which have governed our $1,000 Fellow. These conditions follow:

The year shall be divided into two periods, approximately as follows:

June fifteenth to December fifteenth on Nantucket. This period shall be occupied in observation, research or study, and in lectures or instruction to classes or individuals.

February first to June fifteenth at Harvard College Observatory.

A competitive examination will not be held. The candidate must present evidence of qualifications under the following heads:

1. A letter from the candidate addressed to the Secretary of the Committee, giving an account of previous educational opportunities and training, and of plans for future work.
2. College diploma or a certificate from the registrar of her college, and, if she has already held a position as instructor or teacher in any college or other institution, a clear statement of the work done, together with a certificate as to the quality of work.
3. Examples of work already accomplished.
4. Testimonials as to ability and character.
5. Satisfactory evidence of thoroughly good health.

The Fellowship at all times must be used for purposes of serious study, and the Fellow should be as free as possible from other responsibilities.

The Nantucket Observatory is equipped with a five-inch Alvan Clark visual telescope, a filar micrometer, a seven-and-a-half-inch Cooke photographic telescope, mounted by the Alvan Clark Company, and a micrometer, for measuring Stellar Spectra.

The Committee requests that the application for the $500 Fellowship shall be sent in a year in advance. In order to facilitate the work, the appointment also will be made in advance. It is further requested that the successful candidate for this position shall inform herself as to the special work undertaken by the Maria Mitchell Observatory, and so far as is consistent with her present course of study, shall prepare herself to carry forward the theory and practice of the Nantucket work already undertaken.

Application for the year beginning June 15, 1915, should be made under the the above heads and must be in the hands of the Secretary of the Committee, Mrs. Charles S. Hinchman, 3635 Chestnut Street, Philadelphia, Pennsylvania, on or before April 1, 1914.

The Committee reserves the right to withhold the second or $500 Fellowship in case the work presented to the examiners should not in their judgment be of sufficient merit to deserve the award.

COMMITTEE

ANNIE J. CANNON, A.M., Harvard College Observatory, *Chairman*
PROF. MARY W. WHITNEY,
Director Emeritus of Vassar College Observatory
PROF. ANNE. S. YOUNG, Ph.D., Director of Mt. Holyoke Observatory
DR. EDWARD C. PICKERING, Director of Harvard College Observatory
ELIZABETH R. COFFIN, A.B., Vassar College, 1870.
FLORENCE M. CUSHING, A.B., Vassar College, 1874.
LYDIA S. HINCHMAN, Philadelphia, *Secretary*

The Eiffel Tower Time Signals.—According to a circular, issued Nov. 7, 1913, by President B. Baillaud of the "Bureau international de l'heure," the duration of the "scientific time signals" is to be lengthened to five minutes, and the signals are to be sent out fifteen minutes before the ordinary time signals at night. The change was to go into effect November 15.

The Arlington Radio Signals.—Captain J.L. Jayne, superintendent of the U. S. Naval Observatory, writes under date December 13 that the schedule of signals from Arlington has been changed because of changes necessitated at Paris by the interference from other high power wireless stations near the Eiffel Tower. The schedule maybe changed again.

Present Schedule of Signals from Arlington in Paris-Washington longitude determination:

Arlington sends from 7-44-00 to 7-51-00 Eastern Standard. Time.
" " " 7-53-00 to 8-00-00 " " "
" " " 8-13-00 to 8-20-00 " " "

Concerning some Forces* Affecting Cosmical Motions.—It is well known that many cases of discrepancies have existed between the observed positions of bodies in the solar system and their positions as predicted upon the basis of Newton's law of gravitation. Some of the discrepancies have been explained and removed, whereas others still exist.

Halley's Comet returned to perihelion in March, 1759, several months later than the predicted time. It was not until the discoveries of Uranus and Neptune in 1783 and 1846, respectively, that astronomers were able to explain the discrepancy by virtue of the attractions due to these two planets.

Discrepancies in the motion of Uranus led to the discovery of the disturbing body Neptune in 1846—facts familar to all students of astronomical history.

It has long been known that there are minute discrepancies between the observed and predicted motions of Mercury, Venus, the earth, and Mars. Newcomb's interest in this problem led him to investigate the effects of undiscovered small planets situated between the sun and the orbit of Mercury, or between the orbits of Mercury and Venus, and likewise of the finely divided matter responsible for the zodiacal light; but he concluded that forces due to such masses could not be the causes of the discrepancies. Seeliger's researches, on the contrary, have convinced him and others that the zodiacal-light material may be an extremely important factor in this problem; though perhaps this is not the only factor.

The most noteworthy case of discrepancy relates to our Moon, principally because the relative nearness of the moon to the observer causes the discordances to have considerable angular magnitude; and these remain unexplained.

It is scarcely an exaggeration to say that successive generations of astronomers fully expected that Newton's law would ultimately be found to explain all such discrepancies, either through more perfect methods in the application of the law or through the action of disturbing bodies as yet undiscovered. The recent discoveries of forces and principles possessing quite different natures from those of gravitation have tended to weaken the view that Newton's law is all-sufficient.

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* In this brief note there has been no effort made for completeness, by including eruptive, gas action, convection, and other minor forces; nor by referring to the important investigations of LeVerrier and others.—W.W.C.

Radiation pressure, discovered theoretically by Maxwell and established experimentally by Lebedew and by Nichols and Hull, is far reaching in its consequences upon the cosmical motions of minute particles. In the case of comets' tails, for instance, radiation pressure seems to be more effective than gravitation; but this force appears to be negligible, at least for the present, when we are dealing with relatively large individual masses.

Brown has investigated the possible effects of the earth's magnetic force upon the motion of the moon, only to conclude that this force is ineffective and negligible.

Wacher, Lorentz, and deSitter have discussed the principle of relativity as a possible important factor in explaining existing residuals in the motions of planetary perihelia.

Bottlinger and deSitter have recently investigated the hypothesis that the mutual gravitational attractions of two bodies may be influenced by the passing of a third body between the first two; the intervening body absorbing, in effect, a certain amount of the original attractive force in accordance with laws depending upon the mass penetrated by the lines of force. There is some evidence that this hypothesis is an approximation to a fact of nature.

Hale's recent work has led him to the conclusion that the sun is a weak magnet whose north pole is in a general way situated near the north geographic pole of the sun. That the earth and sun, perhaps the only bodies available for such studies by means of existing resources, should prove to be magnets, of like polarity, argues strongly for the existence of magnetic forces in all other rotating cosmical bodies.

The effects of solar and terrestrial magnetism upon the motions of the sun and earth are no doubt negligible for the present, but may it not be that similar forces under other cosmical conditions are highly effective? Consider the case of a close spectroscopic binary system, whose period of revolution is only a few hours or only a few days. We have very strong reasons for believing that the two massive components are rotating on axes essentially parallel, in the same direction with reference to their surroundings, once in each revolution period. If the rotation of a sun or a planet is an important factor in developing its magnetic field, may not the two rapidly-rotating components of the double-star system be magnets of great strength? Is it not probable, further, that they are of like polarity, since they are rotating in the same direction? Further, as the two bodies are separated by a minute distance, may not their magnetic forces, presumably repellant, be effective in causing their orbits to grow larger. Darwin, Poincaré, and See have contributed to the widely accepted theory that a stellar mass rotating ever more rapidly, to keep pace with decreasing diameter as a result of heat loss, may divide into two components, which continue to revolve around their center of mass in orbits growing larger and larger by virtue of tidal interactions, all operating according to Newton's law and the laws of friction. More recent investigators have questioned the sufficiency of tidal interactions to account for the apparent separation of the two components of a double star beyond certain limits. Might it not be well to make quantitative study of repellant magnetic forces in double-star formation and development, based upon hypothetical cases in harmony with existing knowledge concerning spectroscopic and visual double-star systems. (W.W. CAMPBELL in *Publications of the Astronomical Society of the Pacific*, June 1913.)

A Clock Run by the Weather.—The idea of perpetual motion is very fascinating to certain minds and all sorts of devices have been invented with this end in view. Many attempts have been made to produce a perpetual winding clock, but all have failed because some form of energy was used which in time became

exhausted and had to be renewed by human means. Electric selfwinding clocks may run a year or two without human intervention, but sooner or later the batteries which furnish the winding power must be renewed. In an article on "Perpetual Force Clock Mechanism," in the September 18 number of *The American Machinist*, Mr. Robert Mawson describes a clock that is operated by the expansion and contraction of metal bars due to changes in temperature. By a system of levers, pawls and ratchets the clockweight is raised whenever the temperature rises or falls, so that so long as the weather is fickle the clock will run. The mechanism is so arranged that there is always a reserve supply of energy, so that in case the temperature should remain constant for two months the clock would still run.

As quoted by *The Literary Digest*, October 18, the writer says: "The question might be asked, whether this principle could be used for larger units. Ordinary clocks will run 24 hours with an energy equal to one pound dropping a distance of 21 inches. One horse-power is equivalent to 33,000 pounds moving one foot per minute, or 47,520,000 pounds moving one foot every 24 hours; hence an engine producing one horse-power would be able to run 47,250,000 clocks. Supposing the expansible metal strips to cost only $1 per clock, it would cost $47,520,000 to create a 1 horse-power engine. This would indicate that the principle, though feasible for clock and similar work, is not practicable for larger units."

Blisters on Negatives.—Blisters are perhaps a less common trouble with plates than with papers, but their cause is much the same, as evidenced by the query of a correspondent in a recent issue, in which we read that there was "no appearance of blisters until placed under the tap." The formation of blisters just when a print or plate is taken from the fixing bath and put into water is an almost certain indication of the cause, which in such a case must be the sudden creation in the film of a violent irruptive pressure due to the phenomenon known as osmosis to chemists. The pressure is caused by the rapid entrance of water into the interstices of the film, which are already filled with a fairly concentrated solution of hypo. The water entering far more rapidly than the salt can diffuse out causes a great enlargement of the bulk of liquid within the film, and so tends to raise blisters at all weak points. When this is the cause the phenomenon can be reversed by plunging the plate into a very concentrated solution of hypo, whereupon the water rushes out from the film into the surrounding solution and the blisters subside. If the conditions are equal all over the film of course no blisters will appear, the effect everywhere being the same, but if there are weak spots in the film, such as often occur in the case of prints, then blisters will inevitably appear.

In the case mentioned by our correspondent the washing water was full of air, being milky in appearance from the number of air bubbles it contained. In such a case some parts of the film will be in contact with air only, and the pressure will be localized in the other parts that are in contact with water, and so disruption of the film may occur at these points and blisters be formed. The film may, of course, be weakened by the use of strong alkali or of ammonia or of heat, while the imperfect action of alum or other hardening baths may cause local hardening and leave weaker spots liable to blister. All these are contributory causes, and frequently all exist together, hence it is best as a general rule to avoid creating the conditions that cause blisters. The fixing bath should not be stronger than is really necessary, while the water should not be too pure. Distilled or soft water will produce blisters where tap water will not do so, but safety is best ensured by using some weak bath between the fixing and washing. A salt bath is often recommended, but the salt has no special virtue, and a weak hypo bath is just as effective. Fixing proper

may be accomplished in a 40 per cent bath, which is the quickest in its action. This may be followed by a 10 per cent bath, which will fulfil the double purpose of rendering the fixing quite perfect and also of avoiding blisters, and then the ordinary washing may safely follow. (*British Journal of Photography* May 30, 1913.)

The Gyroscope, by F. J. B. Cordiero. Published by Spon and Chamberlain New York. Price $1.50.

This is a very useful little book, in which the principles and the mathematics pertaining to the gyroscope and its applications are brought together in one volume. The author writes in a very entertaining way and the mathematical treatment is such that it can be easily followed by the student who is familiar with the elementary principles of Mechanics and with the Calculus. The following quotation will illustrate something of the entertaining manner in which the subject is presented:

"The interest of gyroscopes for us, apart from certain recent applications, is manifold. We live in a universe of gyroscopes; everywhere there is rotary motion. We live *on* a gyroscope, and we ride on gyroscopes, be it carriage bicycle, train or aeroplane. Our factories are full of gyroscopes, where occasionally ignorance of gyroscopic laws leads to disaster."

Stellar Motions, with special reference to motions determined by means of the spectrograph, by Wm. W. Campbell, Sc. D., L. L. D., Director of the Lick Observatory. Yale University Press, New Haven, Conn. Price $4.00 net; postage 30cts extra.

For review of this book see POPULAR ASTRONOMY, No. 210, December 1913, p. 608.

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